TRAFFIC QUALITY ON THE ATLANTA REGIONAL HIGHWAY SYSTEM (EXTENSIONS)

(SPRING 2002)

FINAL REPORT

Prepared by
Skycomp, Inc., (Columbia, Maryland)
for the Georgia Department of Transportation

The contents in this publication reflect the views of the author(s), who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Georgia Department of Transportation or the Federal Highway Administration. This publication does not constitute a standard, specification or regulation.

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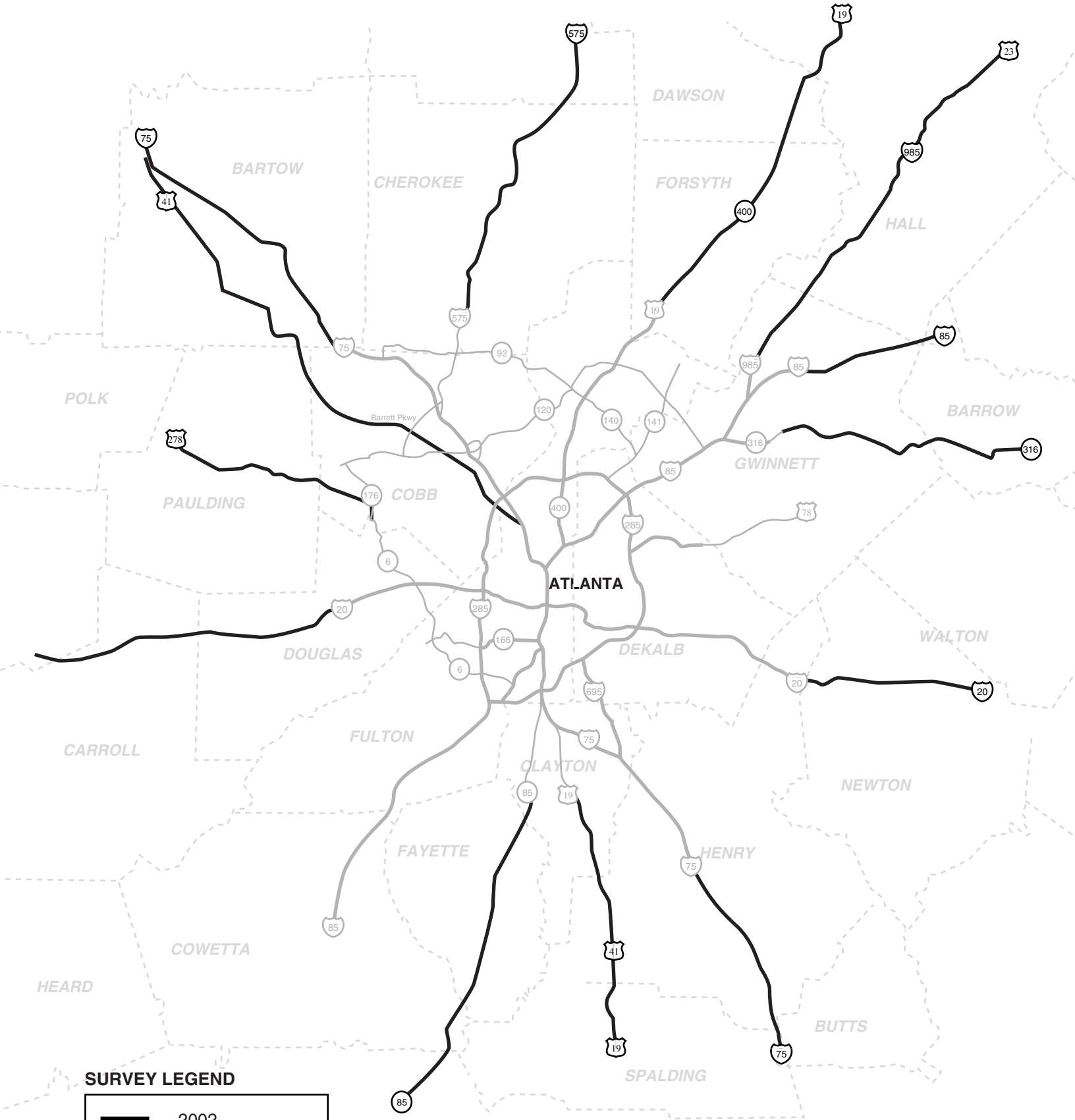
SURVEYED HIGHWAYS



INTRODUCTION

In 1998 and 2001, Skycomp conducted aerial photo surveys of traffic conditions on approximately 500 miles of highways in the greater Atlanta metropolitan region; using the mobility and vantage point of fixed-wing aircraft, a photographic inventory of traffic conditions was made on the backbone of the transportation system. These surveys are part of a 3-year cycle program that allows for monitoring of long term trends. In the spring of 2002, a photo survey ("Atlanta Extensions") was conducted on approximately 300 miles of selected highways that extend outside the original survey area (see opposite page). This report contains findings from that survey; please refer to the report entitled Traffic Quality on the Atlanta Regional Highway System (Fall 2001) for data collected on highways "inside" the extensions.

One of the products of this survey program is a database of traffic conditions on each link of the highway system; the database included with this report will contain data representing conditions found during all three surveys (1998, 2001 and 2002).

FEATURES OF THE AERIAL SURVEY PROGRAM

During this aerial survey program, overlapping photographic coverage was obtained of designated highways, repeated approximately once an hour over three morning and three evening commuter periods. The morning times of coverage were 6:30-9:30 a.m., and evening times were 4:00-7:00 p.m. Survey flights were conducted only on weekdays, except that Monday mornings, Friday evenings and mornings after holidays were excluded. Data were extracted from the aerial photographs such that, by link and by time slice, average recurring daily traffic conditions could be measured. This report presents these measurements in the following ways:

1. Performance rating tables of traffic conditions on the 330 miles of surveyed highways are presented in **Part One** (morning) and **Part Two** (evening) of this report*, on the right-hand side pages*. The ratings are presented in tables by highway segment, by direction and by time slice. Each rating represents the average of approximately four flyovers (from four different days), minus any data affected by incidents. For uninterrupted-flow facilities, the ratings are density-based level-of-service (LOS) designations "A", "B", "C", "D", "E" and "F", as defined in the *2000 Highway Capacity Manual* (HCM). For interrupted-flow facilities, a surrogate level-of-service measure has been used. Developed by Skycomp for use with overlapping aerial photographs, this surrogate measure is based on platoon sizes and queuing characteristics at signalized intersections -- not travel times, which is the defining parameter for arterial LOS in the 2000 HCM. Because this is a surrogate LOS measure, the same letters "A" through "F" have been used; however, these ratings have been underlined to identify them as *surrogate* LOS measures ("A", "B", "C", etc.). NOTE: The procedures for arriving at the performance ratings have been outlined in **Appendix A**.

2. Also in **Part One** and **Part Two** of this report, highway maps containing narratives have been placed opposite each performance-rating table, *on the left-hand side*. These narratives clarify the severity and frequency of all congestion found along each highway segment. Where evident, apparent causes of the problems are also described. Congestion on crossing freeways and on interchange ramps are also depicted and discussed.

3. In order to allow the estimation of vehicle speeds from densities on the freeways, Skycomp has built a database from data collected in Atlanta (in 1998) and other cities demonstrating the precise relationship between traffic densities and speeds. From this database, a look-up table

was developed relating the two variables. The result of Skycomp's work in is provided in **Appendix B**.

4. The dates of all survey flights are presented in **Appendix C**.

5. A primary deliverable for this project is an electronic version of the Survey Database (built in Microsoft Access). This database will be functional and contain all of the collected data, from vehicle counts and road segmentation, to flight information and the variables used to calculate densities. Using this database, a number of reports can be displayed or printed, including segment densities (averaged or by individual observation), vehicle classification, and incident information. Since all data is saved in a relational database, it is possible to customize an unlimited number of queries and reports.

6. An interactive CD-ROM product has been prepared in conjunction with the spring 2002 survey. The **Congestion Highlights** slide show presents the findings of this report, plus many highlight aerial photographs of congestion. This product can be projected to audiences “as is”; the interactive feature allows a presenter to respond to audience interests by going to specific locations as they come up in the discussion.

ACKNOWLEDGMENTS AND DISCLAIMER

Survey operations would not have been possible without the assistance of regional FAA air traffic controllers. Aircraft were furnished by or contracted through the Elite Flight Center in Atlanta, GA.

In order to predict average travel speeds from traffic densities, a staff member of the Metropolitan Washington, D.C. Council of Governments (Paul DeVivo) calibrated a single-regime model developed by Michel Van Aerde for use in the metropolitan Washington area. The model was submitted by Van Aerde to the Transportation Research Board in 1995 (TRB Paper No. 95082; see also discussion in Appendix B).

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QUESTIONS

If there are any questions about this survey program or the underlying methodology, please direct them to Ken Stanek at 410-884-6900.

- **FREEWAY LEVEL-OF-SERVICE RATINGS**
- **ARTERIAL LEVEL-OF-SERVICE RATINGS**

FREEWAY LEVEL-OF-SERVICE RATINGS (UNINTERRUPTED-FLOW FACILITIES):

(NOTE: LEVEL-OF-SERVICE RATINGS ARE BASED ON AVERAGE DENSITIES BETWEEN INTERCHANGES, WHICH ARE GENERALLY GREATER THAN ONE MILE APART. THE EFFECTS OF INCIDENTS AND TEMPORARY ROADWORK HAVE BEEN REMOVED FROM ALL RATINGS BEFORE AVERAGING.)

Level-of-service A: Light traffic flow, at free-flow speeds.

Level-of-service B: Light-to-moderate traffic flow, at free-flow speeds.

Level-of-service C: Moderate traffic flow, usually at free-flow speeds; freedom to maneuver somewhat restricted.

Level-of-service D: Moderate to heavy traffic flow; speeds can be slightly below free-flow; freedom to maneuver significantly restricted.

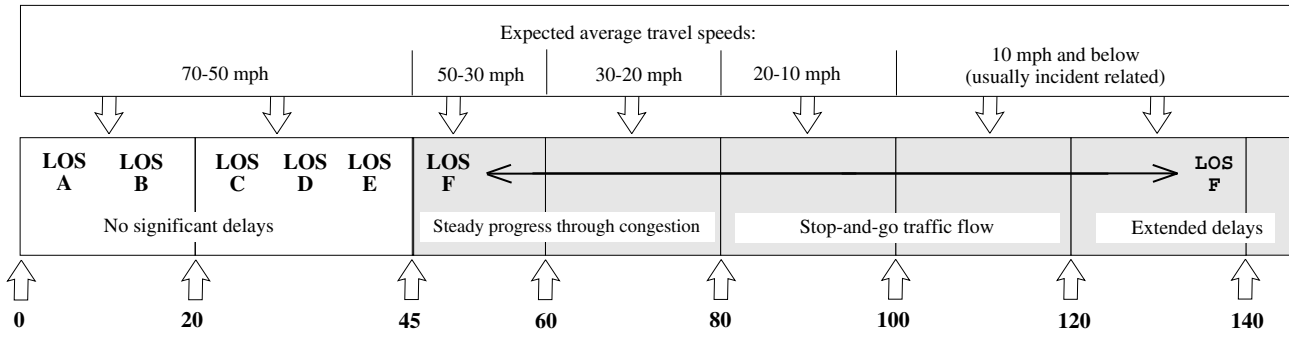
Level-of-service E: Heavy traffic flow, at speeds typically between 60 and 40 mph. Little or no capacity to absorb additional traffic.

Level-of-service F: Congested traffic flow, with speeds that can range from below 5 mph almost up to 60 mph. For this reason, all "F" ratings have been augmented with average density values, which provide greater insight into the nature of the traffic flow (units are passenger cars per lane-mile):

> **Densities from 46 to 60**: "level-of-service "F" traffic flow averaging approximately 50-30 mph;
>
> **Densities from 60 to 80**: "slow-then-go" traffic flow (some stopping can occur); traffic flow averaging approximately 40-15 mph;
>
> **Densities from 80 to 100**: typically associated with "stop-and-go" traffic flow; average travel speeds approximately 25-10 mph. This is the upper boundary that daily congestion is normally measured at.
>
> *(Densities above 100 for the full length of a segment usually indicate the presence of an incident or construction.)*
>
> **Densities from 100 to 120**: Average travel speeds typically between 15 and 5 mph. In rare cases, daily congestion can be measured at this level, especially for short bottleneck segments.
>
> **Densities from 120 to 180**: severe congestion associated with incidents or construction (180 is the highest density measured by Skycomp, with a corresponding average travel speed below 5 mph).

(For more information, refer to "Procedures for determining freeway level-of-service" in the Appendix A. These service level definitions are based on the 2000 Highway Capacity Manual.)

SUMMARY OF FREEWAY TRAFFIC QUALITY RATINGS
(DENSITY-BASED LEVEL-OF-SERVICE)



DENSITY (passenger cars per lane per mile)

These service level definitions are based on the 2000 Highway Capacity Manual

ARTERIAL HIGHWAY TRAFFIC QUALITY RATINGS (INTERRUPTED-FLOW FACILITIES)*:

(NOTE: THESE DESCRIPTIONS APPLY TO TRAVEL ALONG HIGHWAY SEGMENTS, WHICH ARE GENERALLY GREATER THAN ONE MILE IN LENGTH; CONGESTED INTERSECTIONS WITHIN EACH SEGMENT ARE REPORTED SEPARATELY. THE EFFECTS OF INCIDENTS AND TEMPORARY ROADWORK HAVE BEEN REMOVED FROM ALL RATINGS BEFORE AVERAGING.)

Arterial quality level A: Very light traffic flow; few cars using the roadway.

Arterial quality level B: Light traffic flow; little or no platooning.

Arterial quality level C: Moderate traffic flow; platoon populations under 15 vehicles per lane.

Arterial quality level D: Heavy traffic flow; queuing at signals, but all should clear on green (less than 20 vehicles per lane); platoon populations between 15 and 25 vehicles per lane.

Arterial quality level E: Congested traffic flow; large queues (20-40 vehicles per lane) at one or two intersections; slow-moving platoons of greater than 25 vehicles per lane (if one lane, resembles a funeral procession). Also may designate intermittent "F" congestion.

Arterial quality level F: Severely congested traffic flow, usually exhibiting either: 1) traffic backing through upstream signal(s); 2) a series of intersections with large queues (20-40 vehicles per lane); or 3) greater than 40 vehicles per lane queued at one intersection.

* (While these are not arterial level-of-service ratings, they are consistent with the qualitative descriptions of each service level as described on page 11-4 of the 2000 Highway Capacity Manual. They do not represent travel time measurements, however, which are the basis for calculating arterial service level ratings.)

(For more information, refer to "Procedures for determining arterial highway traffic conditions" in the Appendix A.)

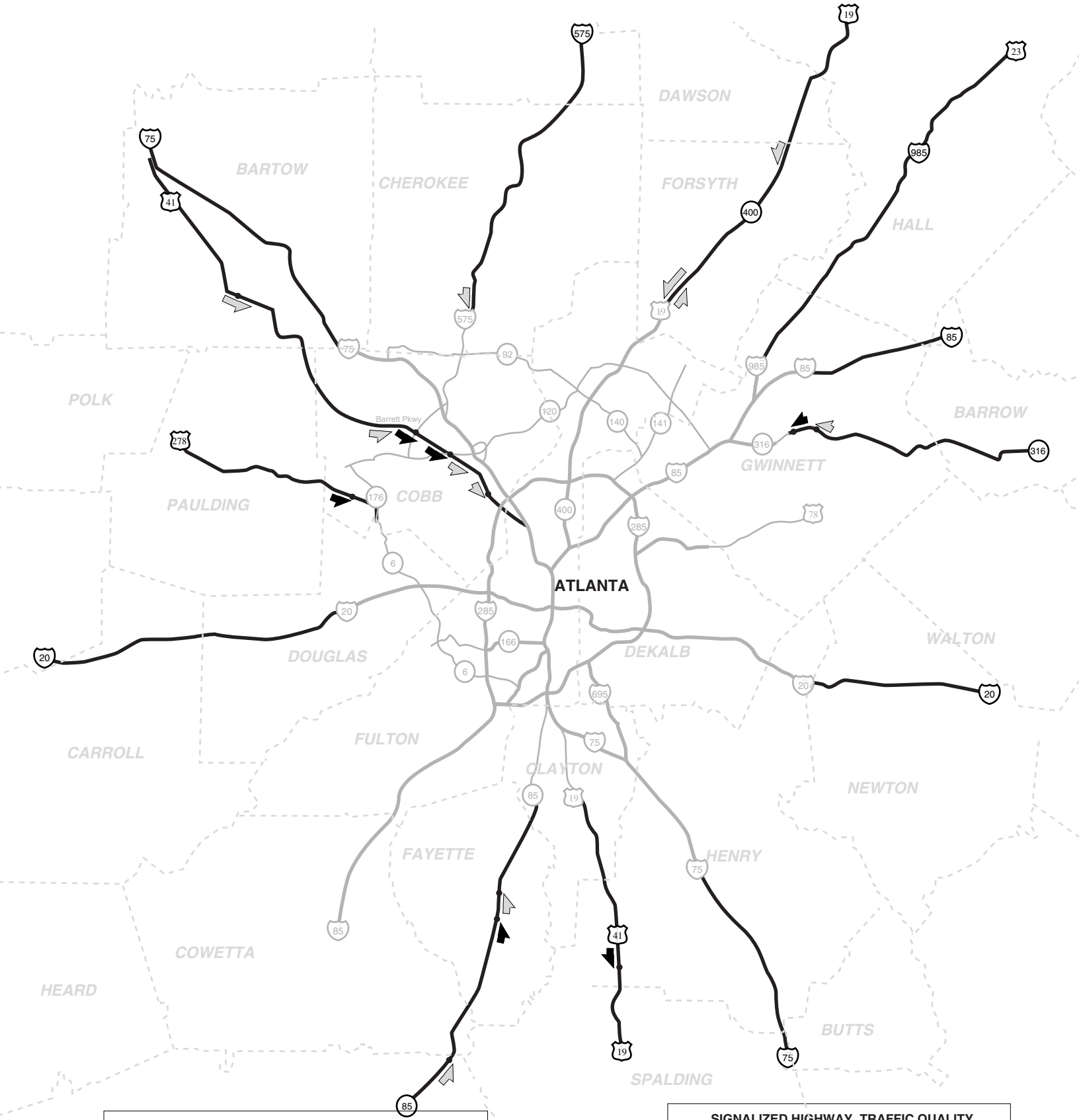
SUMMARY OF ARTERIAL HIGHWAY TRAFFIC CONDITION RATINGS (SURROGATE LEVEL-OF-SERVICE)

Performance ratings on interrupted-flow segments which are generally 1 to 3 miles in length:					
A	**B**	**C**	**D**	**E**	**F**
Very light traffic; few cars on road.	Light traffic; little or no platooning.	Moderate traffic; platoons less than 15 veh. per lane.	Heavy traffic; platoons between 15 and 25 veh. per lane.	Congested traffic; platoons more than 25 veh. per lane; large queues at 1 or 2 intersections.	Severely congested traffic; queuing thru upstream signal(s); series of congested intersections.

(Surrogate level-of-service ratings (underlined) are not travel-time based; however, qualitative descriptions of traffic flow at each service level in Chapter 11 of the 2000 Highway Capacity Manual were used in development of this rating system.)

Rating system developed by SKYCOMP, Inc. Columbia MD, for use with overlapping aerial photographs of highway segments.

LOCATIONS WHERE CONGESTION WAS FOUND (MORNING)



HIGHWAY TRAFFIC QUALITY

- Congested flow at average speeds of 30-50 mph
- Congested flow involving varying degrees of stop-and-go (average speeds < 30 mph)

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

MORNING

A summary of conditions found on the surveyed highways in 2002 is provided below. For more detail on all highways surveyed, including level-of-service and specifics on congestion found, please refer to Part One.

US 19/41
(Clayton / Henry / Spalding Counties)
For the most part, traffic in each direction on US 19/41 progressed steadily without major delay. However, the signal at SR 92 (McIntosh Rd) did generate southbound congestion during the peak period; queue populations typically ranged from 20 to 25 vehicles per lane (two lanes).

I-20 East & West
(Newton / Carroll / Douglas Counties)
No congestion was found on I-20 during the morning survey period.

US 23
(Hall County)
No congestion was found on US 23 in Hall County during the morning survey period.

US 41 North
(Bartow County / Cobb County)
Two zones of congestion were found on US 41 during the morning survey period. To the north in Bartow County, the signals at Mac Johnson Rd and Grassdale Rd generated southbound queue populations of 20 to 30 vehicles per lane (two lanes). After clearing these signals, thru-traffic on US 41 typically progressed steadily southbound for ten to twelve miles before encountering congestion in Cobb County. Between SR 176 and N. Marietta Parkway, signal queues ranged widely, from 20 to 75 vehicles per lane (two lanes); the primary bottlenecks were found at Jiles Rd, Canton Rd Connector and Allgood Rd. South of Marietta Parkway, southbound travelers typically progressed steadily to Perimeter, and farther south to I-75.

I-75 North & South
(Bartow / Henry Counties)
No congestion was found on I-75 during the morning survey period.

I-85 North
(Gwinnett / Barrow Counties)
No congestion was found on I-85 in Gwinnett or Barrow Counties during the morning survey period.

SR 85 South
(Fayette County)
For the most part, traffic in each direction on SR 85 progressed steadily without major delay. However, the signal at SR 92 (Lee St) did generate northbound congestion during the peak period; queue populations typically ranged from 20 to 30 vehicles per lane (two lanes).

US 278
(Cobb / Paulding Counties)
For the most part, traffic in each direction on US 278 progressed steadily without major delay. However, the signal at SR 92 (Hiram Douglasville Hwy) did generate eastbound congestion during the peak period; queue populations typically ranged from 20 to 25 vehicles per lane (two lanes).

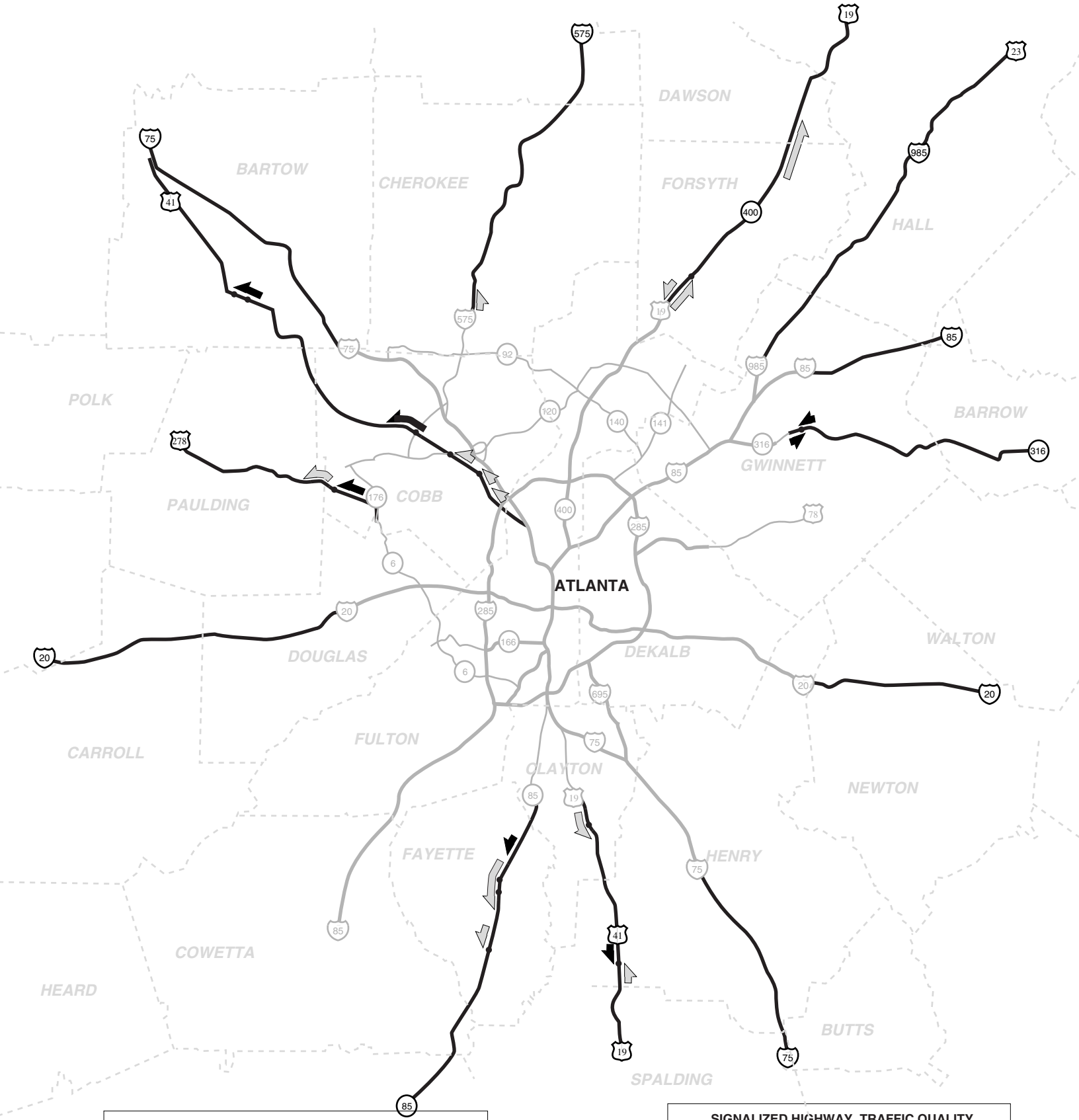
SR 316
(Gwinnett / Barrow Counties)
To the east in Barrow County, traffic in each direction on SR 316 progressed steadily without significant delays. In Gwinnett County, westbound congestion was found approaching the signals at US 29 (Winder Hwy) and SR 20. The primary bottleneck was at SR 20 where queue populations ranged from 30 to 85 vehicles per lane (two lanes).

I-575
(Cherokee County)
For the most part, traffic in each direction on I-575 traveled at free flow speeds. However, early in the survey period, a short zone of southbound congestion was found in the vicinity of the interchange at Towne Lake Parkway where traffic entered I-575.

I-985
(Gwinnett / Hall Counties)
No congestion was found on I-985 in Gwinnett or Hall Counties during the morning survey period.

SR 400 / US 19
(Forsyth / Dawson Counties)
In Forsyth County, congestion was found in each direction on SR 400 between McFarland Rd and SR 120; the primary bottleneck was found at Windward Parkway where traffic entered SR 400; in the southbound direction, average speeds along this 2 to 3 mile corridor ranged from approximately 25 to 40 mph. Construction at the Windward Parkway interchange may have contributed to the congestion.

LOCATIONS WHERE CONGESTION WAS FOUND (EVENING)



HIGHWAY TRAFFIC QUALITY

- Congested flow at average speeds of 30-50 mph
- Congested flow involving varying degrees of stop-and-go (average speeds < 30 mph)

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

EVENING

A summary of conditions found on the surveyed highways in 2002 is provided below. For more detail on all highways surveyed, including level-of-service and specifics on congestion found, please refer to Part Two.

US 19/41
(Clayton / Henry / Spalding Counties)
For the most part, traffic in each direction on US 19/41 progressed steadily without major delay. However, the signal at SR 92 (McIntosh Rd) did generate southbound congestion during the peak period; queue populations typically ranged from 20 to 35 vehicles per lane (two lanes).

I-20 East & West
(Newton / Carroll / Douglas Counties)
No congestion was found on I-20 during the evening survey period.

US 23
(Hall County)
No congestion was found on US 23 in Hall County during the evening survey period.

US 41 North
(Bartow County / Cobb County)
Similar to the morning survey period, two zones of congestion were found on US 41 during the evening survey period. To the south in Cobb County, northbound congestion was found between Marietta Parkway and SR 176; the primary bottlenecks were found at McCollum Parkway, Kennesaw Due West Rd and Acworth Due West Rd. Queue populations at these signals typically ranged from 20 to 50 vehicles per lane (two lanes). After clearing these signals, thru-traffic on US 41 typically progressed steadily northbound for ten to twelve miles before encountering congestion in Bartow County; as was found in the morning, the signals at Grassdale Rd and Mac Johnson Rd generated congestion; northbound queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

I-75 North & South
(Bartow / Henry Counties)
No congestion was found on I-75 during the evening survey period.

I-85 North
(Gwinnett / Barrow Counties)
No congestion was found on I-85 in Gwinnett or Barrow Counties during the evening survey period.

SR 85 South
(Fayette County)
During the evening survey period, southbound congestion was found on SR 85 approaching the series of signals in Fayetteville; the primary bottleneck was found at Banks Rd where queue populations during the peak period ranged from 20 to 60 vehicles per lane (two lanes).

US 278
(Cobb / Paulding Counties)
For the most part, traffic in each direction on US 278 progressed steadily without major delay. However, similar to the morning survey, the signal at SR 92 (Hiram Douglasville Hwy) generated significant congestion; during the peak period, westbound queue populations ranged widely, from 30 to 60 vehicles per lane (two lanes).

SR 316
(Gwinnett / Barrow Counties)
To the east in Barrow County, traffic in each direction on SR 316 progressed steadily without significant delays. In Gwinnett County, eastbound and westbound congestion was found approaching SR 20; queue populations here typically ranged from 20 to 40 vehicles per lane (two lanes).

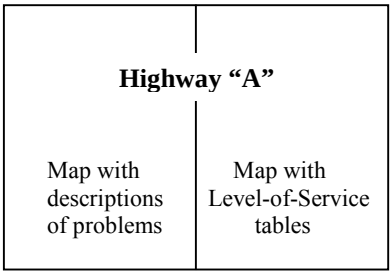
I-575
(Cherokee County)
For the most part, traffic in each direction on I-575 traveled at free flow speeds. However, similar to the evening survey, a short zone of congestion was found in the vicinity of the interchange at Towne Lake Parkway (northbound) where traffic entered I-575.

I-985
(Gwinnett / Hall Counties)
No congestion was found on I-985 in Gwinnett or Hall Counties during the evening survey period.

SR 400 / US 19
(Forsyth / Dawson Counties)
In Forsyth County, congestion was found in each direction on SR 400 between SR 120 and Windward Parkway; average speeds along this two-mile corridor ranged from approximately 30 to 50 mph. Construction at the Windward Parkway interchange appeared to be the bottleneck in the northbound direction.

PART ONE

MORNING SURVEY PERIOD



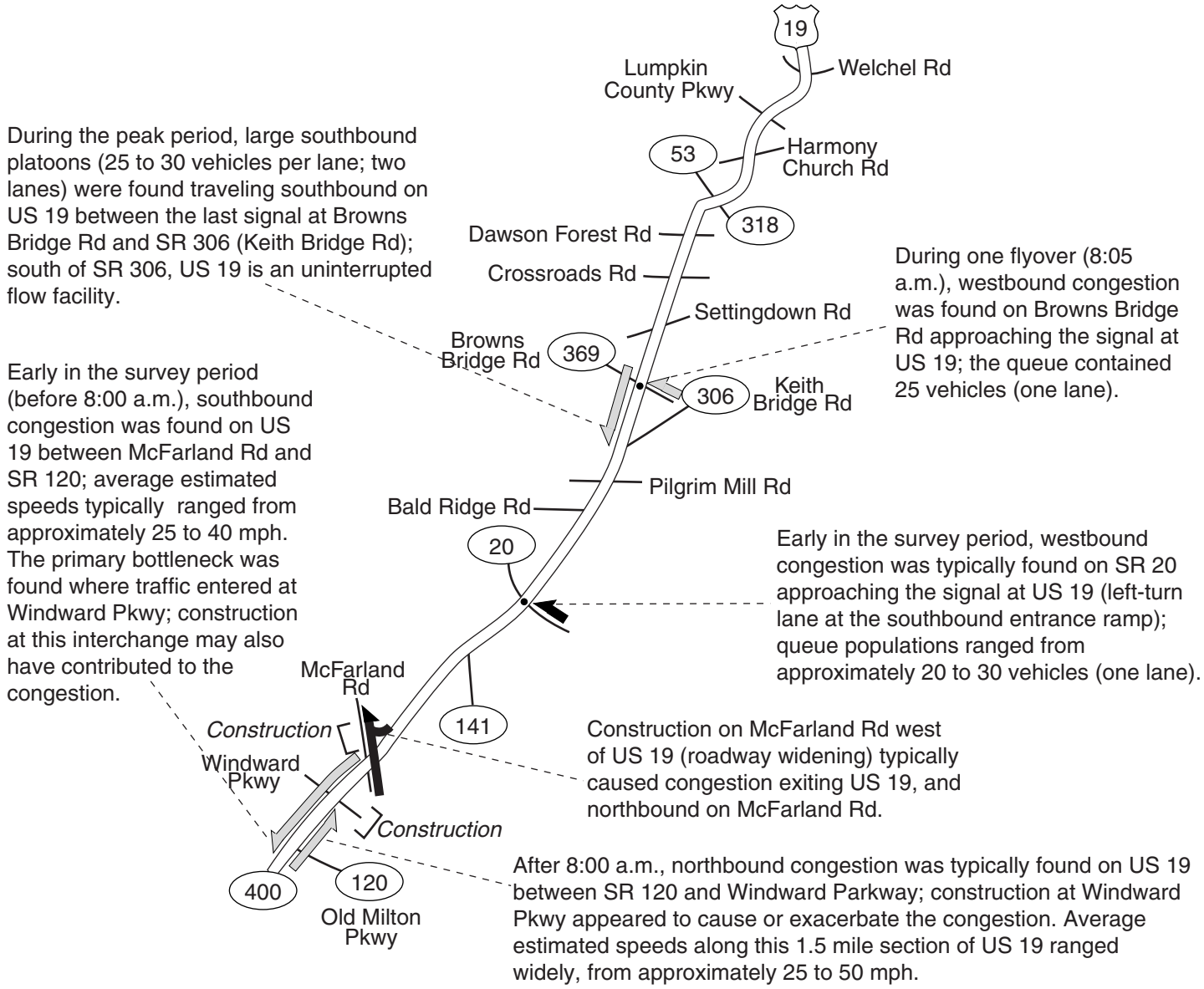
Each highway is presented in a set of opposing maps. The maps with the technical tables on the right contain averaged level-of-service ratings, minus the effects of any known or suspected incidents (actual density values are provided for all LOS "F" ratings). Details are presented in narratives on the left.

Highways are presented in the following order:

- US 19 / SR 400
- US 19/41 (S)
- I-20 (E)
- I-20 (W)
- US 23
- US 41 (N)
- I-75 (N)
- I-75 (S)
- I-85 (N)
- SR 85
- US 278
- SR 316
- I-575
- I-985

Exit numbers for each roadway are assigned by Skycomp, Inc.

US ROUTE 19 / SR 400
MORNING
(Forsyth / Dawson Counties)



During the peak period, large southbound platoons (25 to 30 vehicles per lane; two lanes) were found traveling southbound on US 19 between the last signal at Browns Bridge Rd and SR 306 (Keith Bridge Rd); south of SR 306, US 19 is an uninterrupted flow facility.

During one flyover (8:05 a.m.), westbound congestion was found on Browns Bridge Rd approaching the signal at US 19; the queue contained 25 vehicles (one lane).

Early in the survey period (before 8:00 a.m.), southbound congestion was found on US 19 between McFarland Rd and SR 120; average estimated speeds typically ranged from approximately 25 to 40 mph. The primary bottleneck was found where traffic entered at Windward Pkwy; construction at this interchange may also have contributed to the congestion.

Early in the survey period, westbound congestion was typically found on SR 20 approaching the signal at US 19 (left-turn lane at the southbound entrance ramp); queue populations ranged from approximately 20 to 30 vehicles (one lane).

Construction on McFarland Rd west of US 19 (roadway widening) typically caused congestion exiting US 19, and northbound on McFarland Rd.

After 8:00 a.m., northbound congestion was typically found on US 19 between SR 120 and Windward Parkway; construction at Windward Pkwy appeared to cause or exacerbate the congestion. Average estimated speeds along this 1.5 mile section of US 19 ranged widely, from approximately 25 to 50 mph.

HIGHWAY TRAFFIC QUALITY

Congested flow at average speeds of 30-50 mph

Congested flow involving varying degrees of stop-and-go (average speeds < 30 mph)

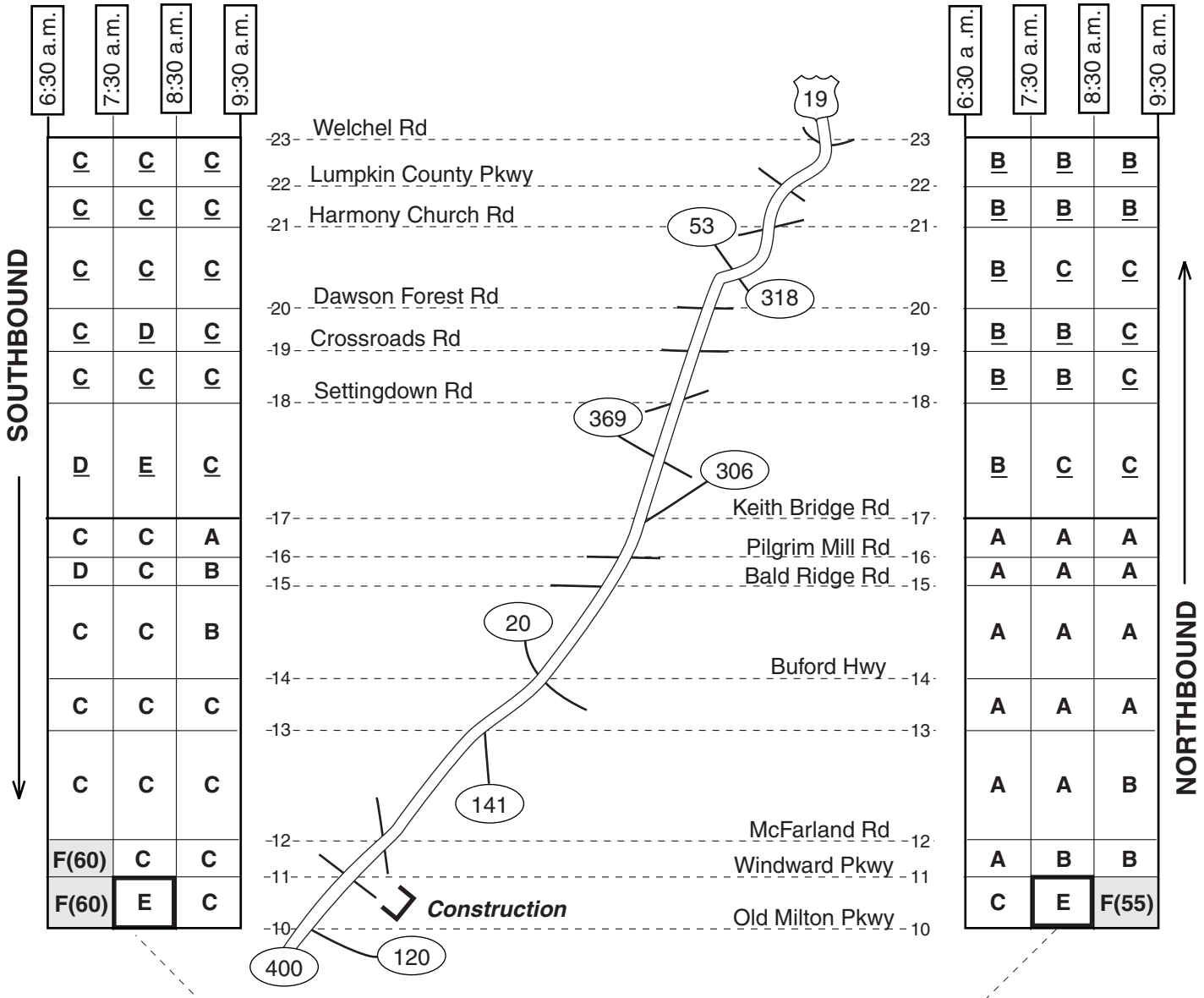
SIGNALIZED HIGHWAY TRAFFIC QUALITY

Intermittent congestion or slow moving platoons along a highway segment

Congested Signalized Intersection (intermittent)

Congested Signalized Intersection (continuous)

US ROUTE 19 / SR 400
MORNING
(Forsyth / Dawson Counties)



On some days and not others, congestion was found on this segment of SR 400; when congested, average speeds were estimated at approximately 30 to 40 mph.

SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

LEVEL-OF-SERVICE LEGEND:

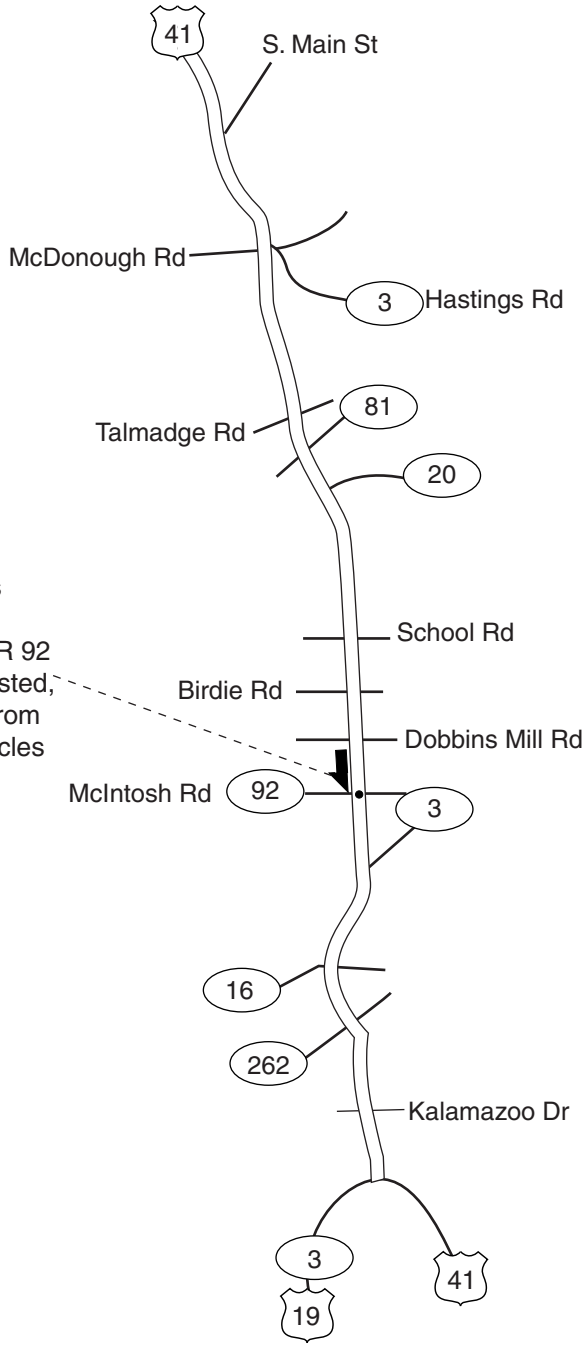
LIGHT	MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F	F

0 10 20 30 45 65

Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

US 19/41 SOUTH
MORNING
(Clayton / Henry / Spalding Counties)

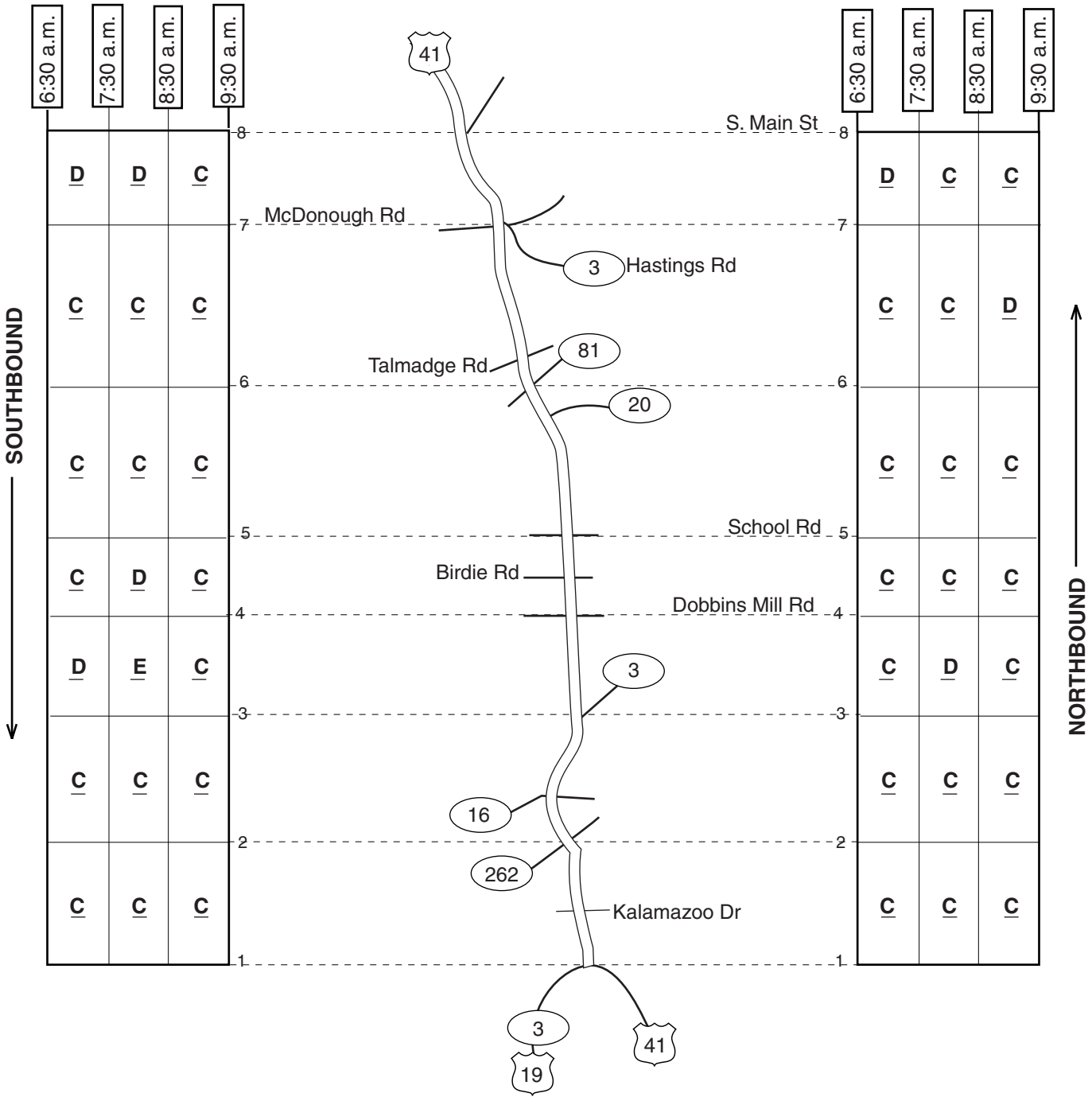


During the peak period, southbound congestion was typically found on US 19/41 approaching the signal at SR 92 (McIntosh Rd); when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two lanes).

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

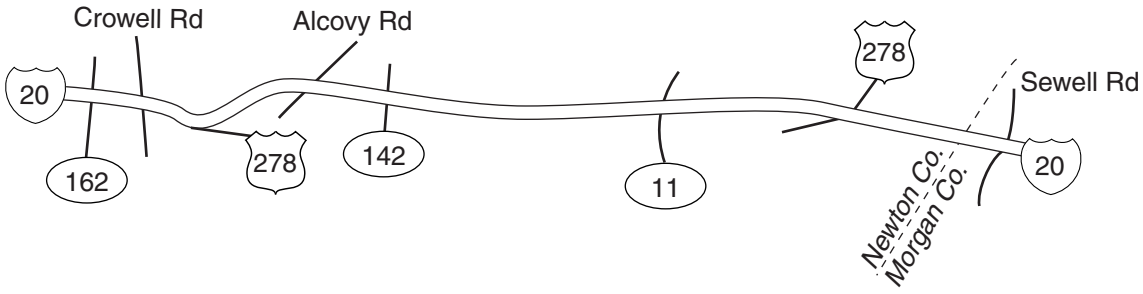
US 19/41 SOUTH
MORNING
(Clayton / Henry / Spalding Counties)



SURROGATE LEVEL-OF-SERVICE LEGEND:

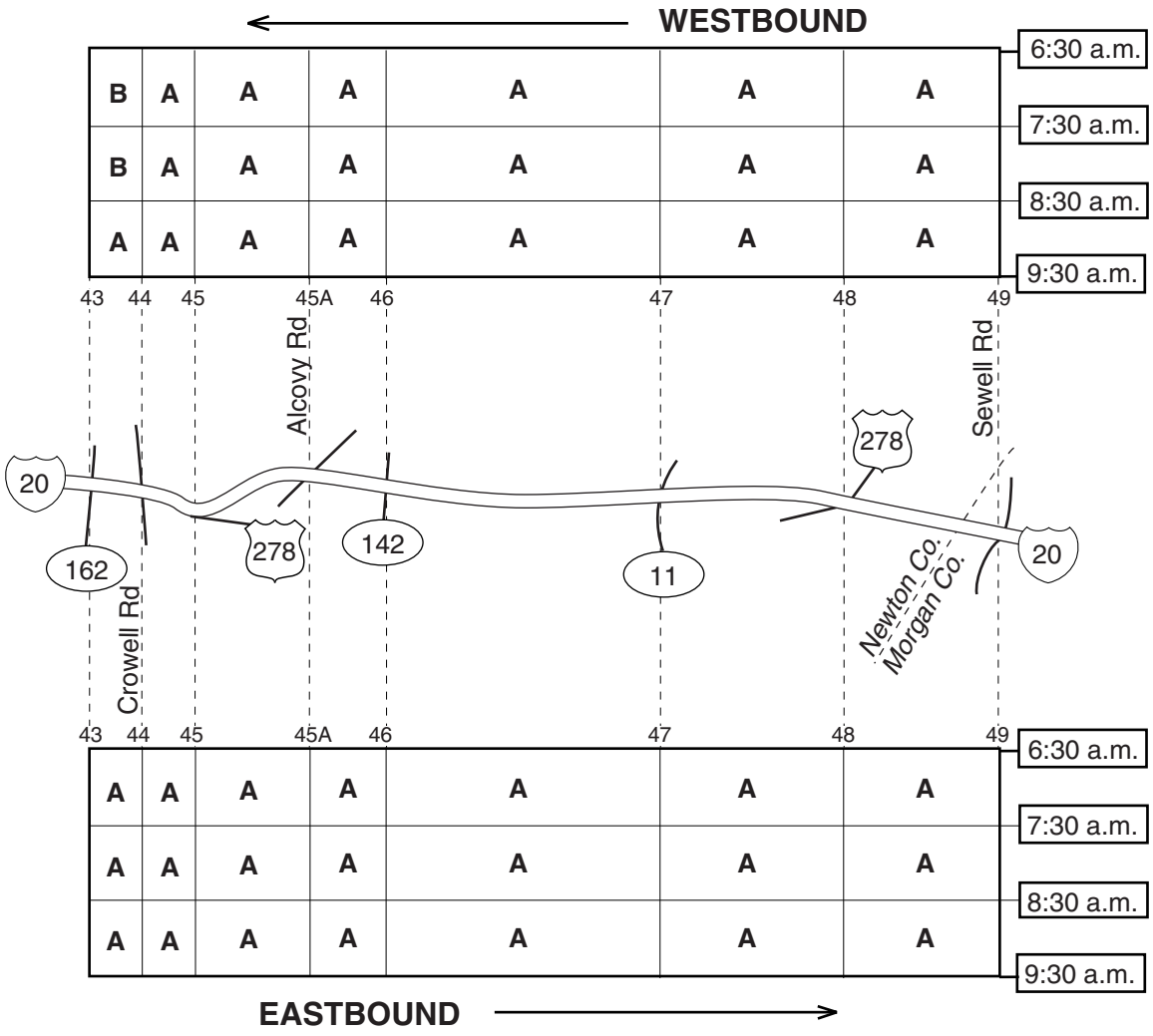
LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

I-20 EAST
MORNING
(Newton County)



No congestion was found on I-20 (East) during
the morning survey period.

I-20 EAST
MORNING
(Newton County)



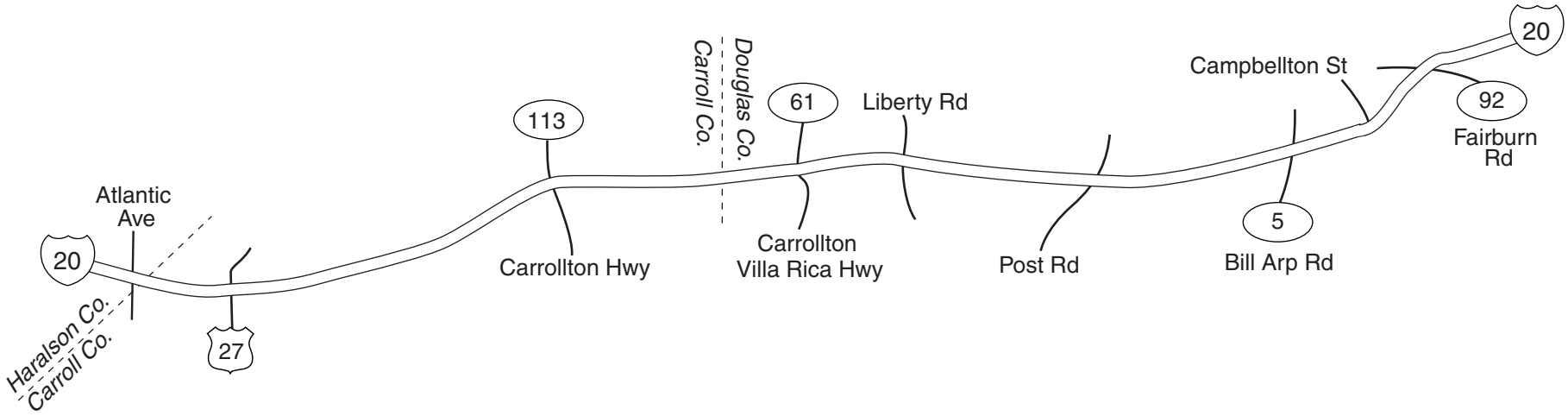
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F		F
0	10	20	30	45	65		

Density scale (cars per lane-mile)

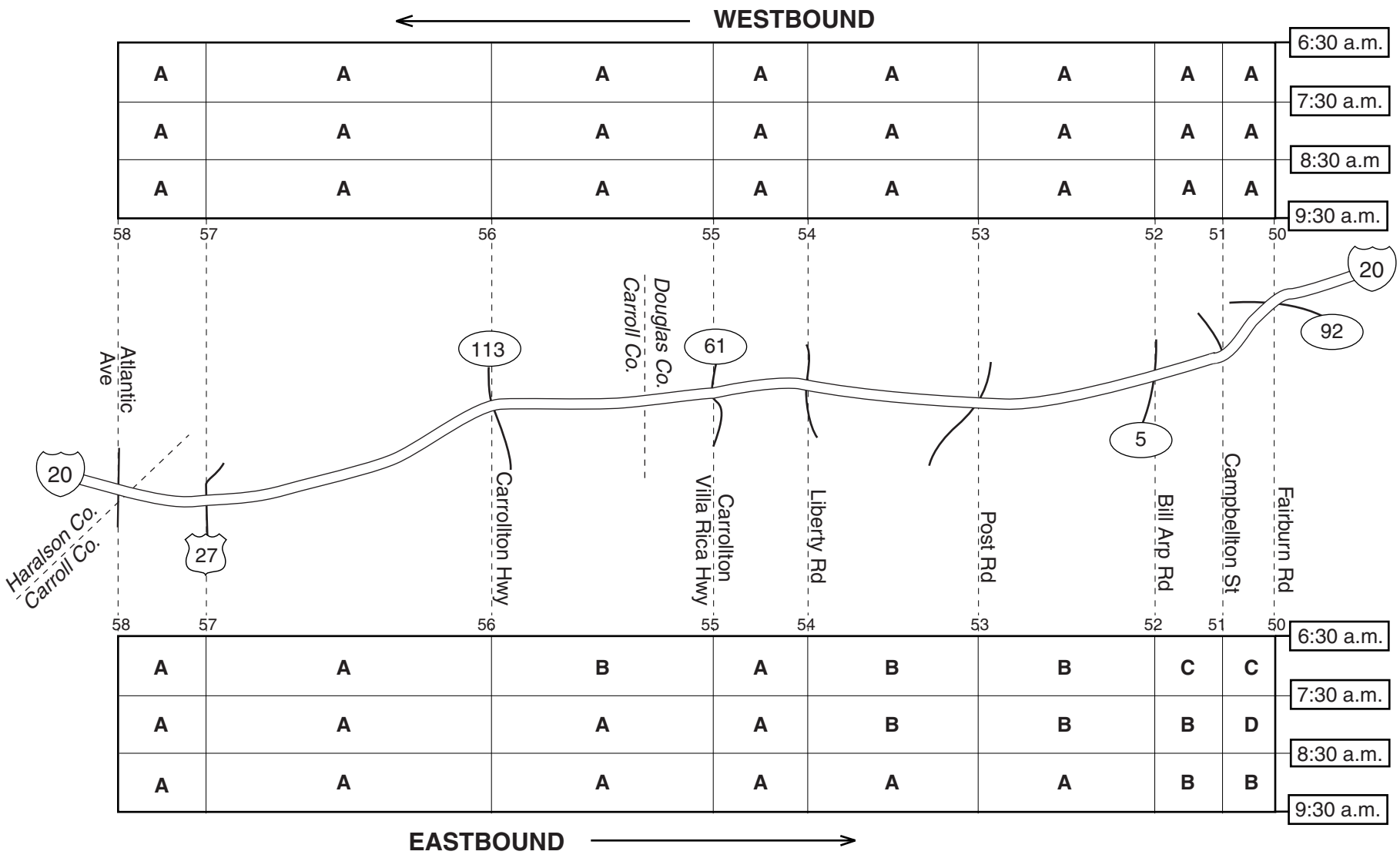
Note: F (60) in the tables means level-of-service "F", with density = 60

I-20 WEST
MORNING
(Carroll / Douglas Counties)



No congestion was found on I-20 (West) during the morning survey period.

I-20 WEST
MORNING
(Carroll / Douglas Counties)



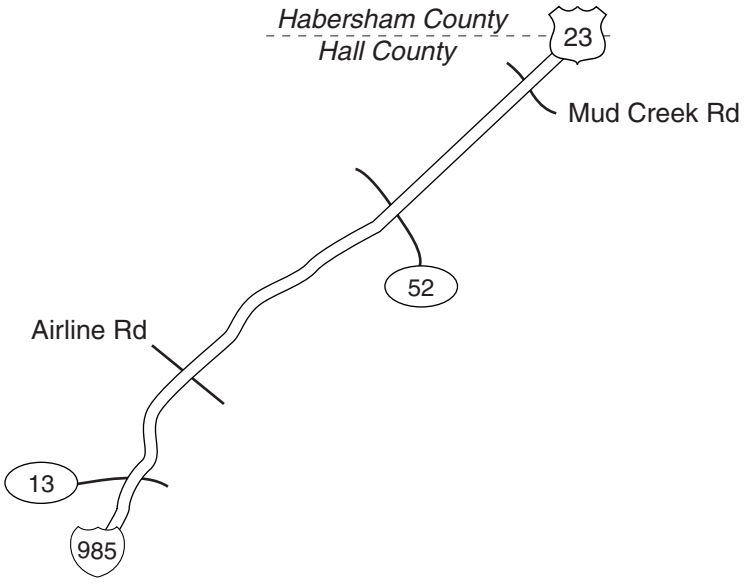
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

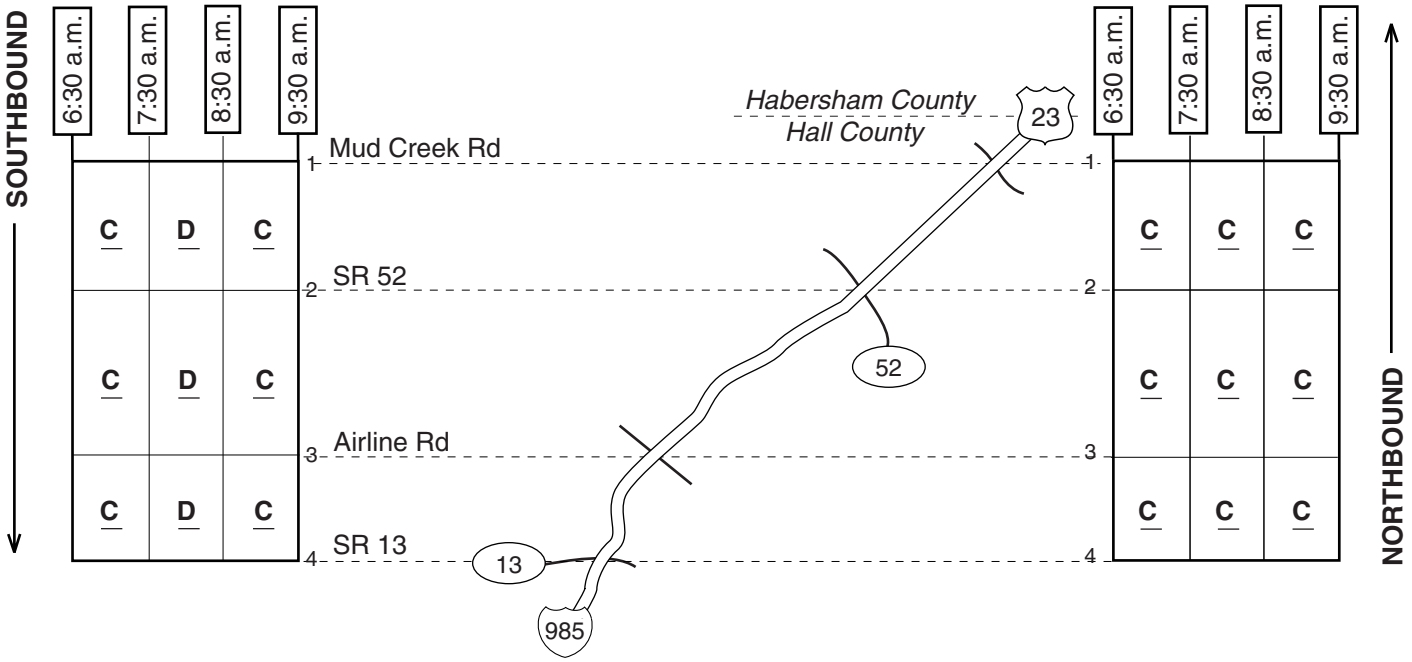
Note: F (60) in the tables means level-of-service "F", with density = 60

US 23
MORNING
(Hall County)



No congestion was found on US Route 23 during the morning survey period; however, during the peak period, platoon populations ranging from 15 to 25 vehicles per lane were typically found traveling southbound between the Habersham County Line and SR 13.

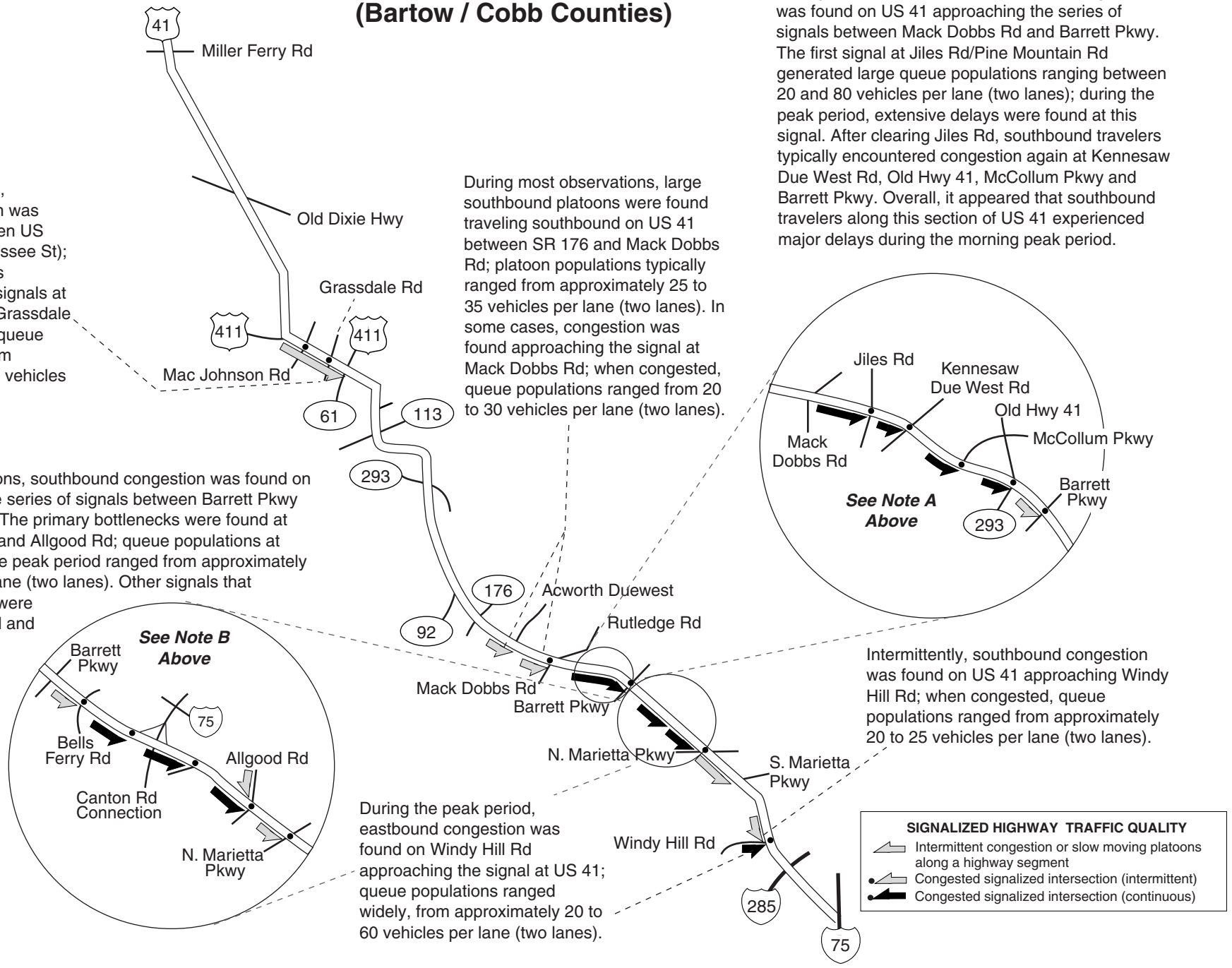
US 23
MORNING
(Hall County)



SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

US 41 NORTH
MORNING
(Bartow / Cobb Counties)



During the peak period, southbound congestion was found on US 41 between US 411 and SR 61 (Tennessee St); the primary bottlenecks appeared to be at the signals at Mac Johnson Rd and Grassdale Rd. When congested, queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

During most observations, large southbound platoons were found traveling southbound on US 41 between SR 176 and Mack Dobbs Rd; platoon populations typically ranged from approximately 25 to 35 vehicles per lane (two lanes). In some cases, congestion was found approaching the signal at Mack Dobbs Rd; when congested, queue populations ranged from 20 to 30 vehicles per lane (two lanes).

Note A:
During most observations, southbound congestion was found on US 41 approaching the series of signals between Mack Dobbs Rd and Barrett Pkwy. The first signal at Jiles Rd/Pine Mountain Rd generated large queue populations ranging between 20 and 80 vehicles per lane (two lanes); during the peak period, extensive delays were found at this signal. After clearing Jiles Rd, southbound travelers typically encountered congestion again at Kennesaw Due West Rd, Old Hwy 41, McCollum Pkwy and Barrett Pkwy. Overall, it appeared that southbound travelers along this section of US 41 experienced major delays during the morning peak period.

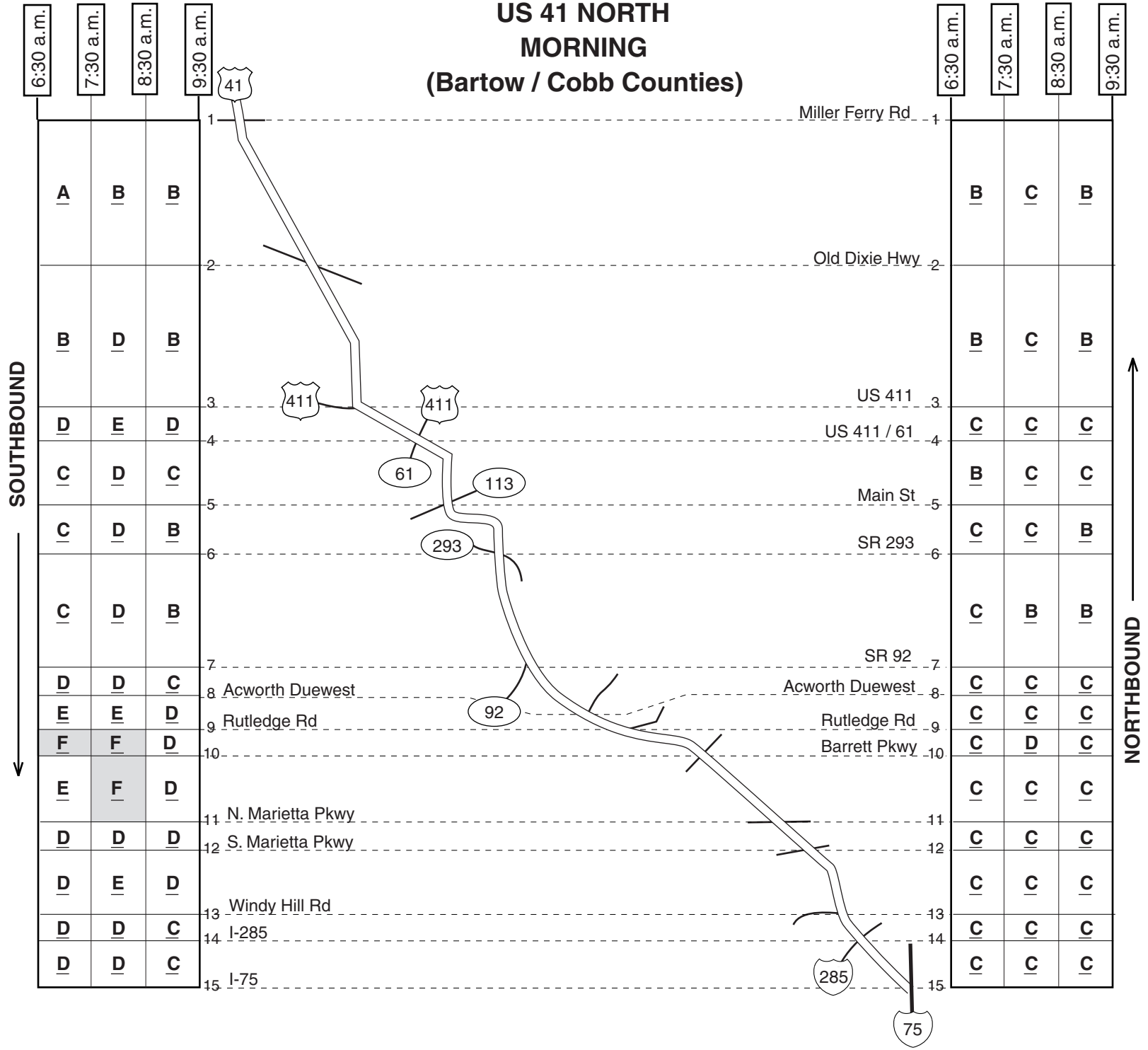
Note B:
During most observations, southbound congestion was found on US 41 approaching the series of signals between Barrett Pkwy and N. Marietta Pkwy. The primary bottlenecks were found at Canton Rd Connector and Allgood Rd; queue populations at these signals during the peak period ranged from approximately 20 to 75 vehicles per lane (two lanes). Other signals that generated congestion were found at Bells Ferry Rd and N. Marietta Pkwy.

Intermittently, westbound congestion was found on Allgood Rd approaching the signal at US 41; when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two lanes).

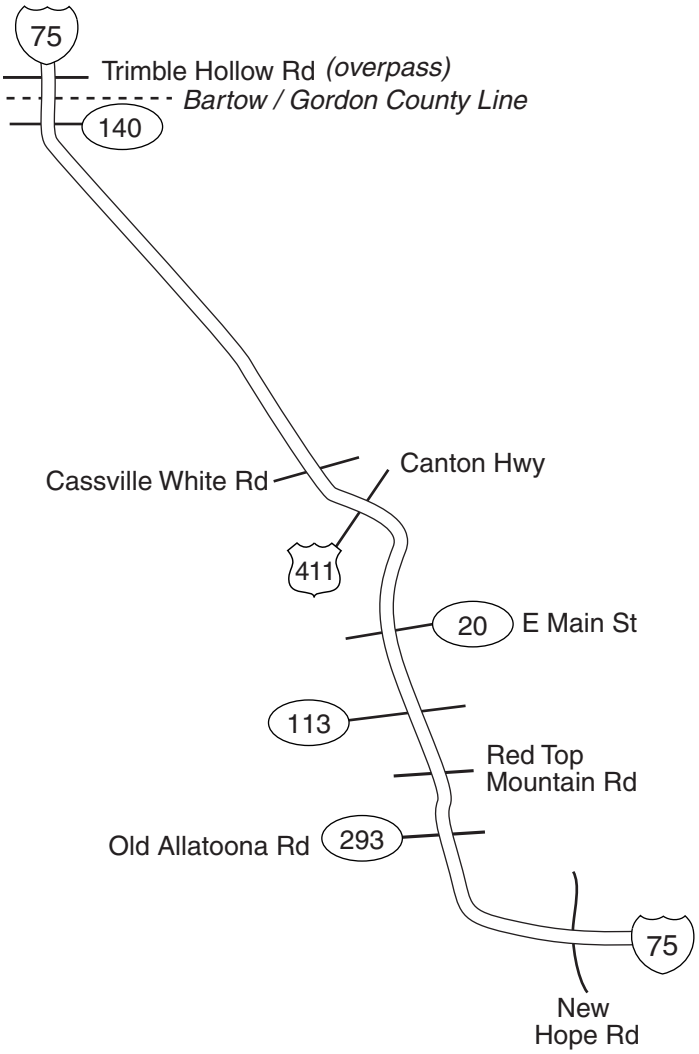
Intermittently, southbound congestion was found on US 41 approaching Windy Hill Rd; when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two lanes).

During the peak period, eastbound congestion was found on Windy Hill Rd approaching the signal at US 41; queue populations ranged widely, from approximately 20 to 60 vehicles per lane (two lanes).

US 41 NORTH
MORNING
(Bartow / Cobb Counties)

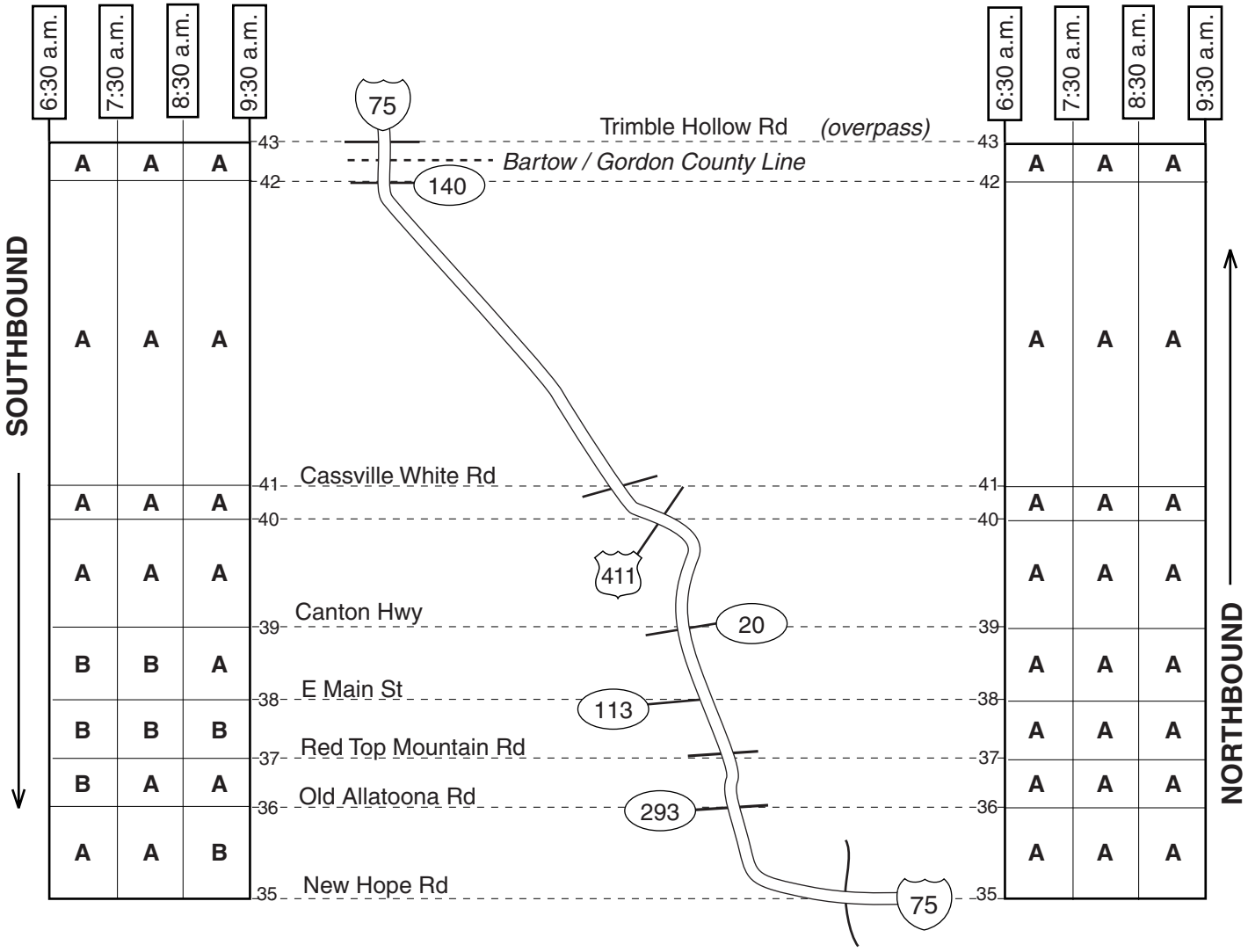


I-75 NORTH
MORNING
(Bartow County)



No congestion was found on I-75 (North)
during the morning survey period.

I-75 NORTH
MORNING
(Bartow County)



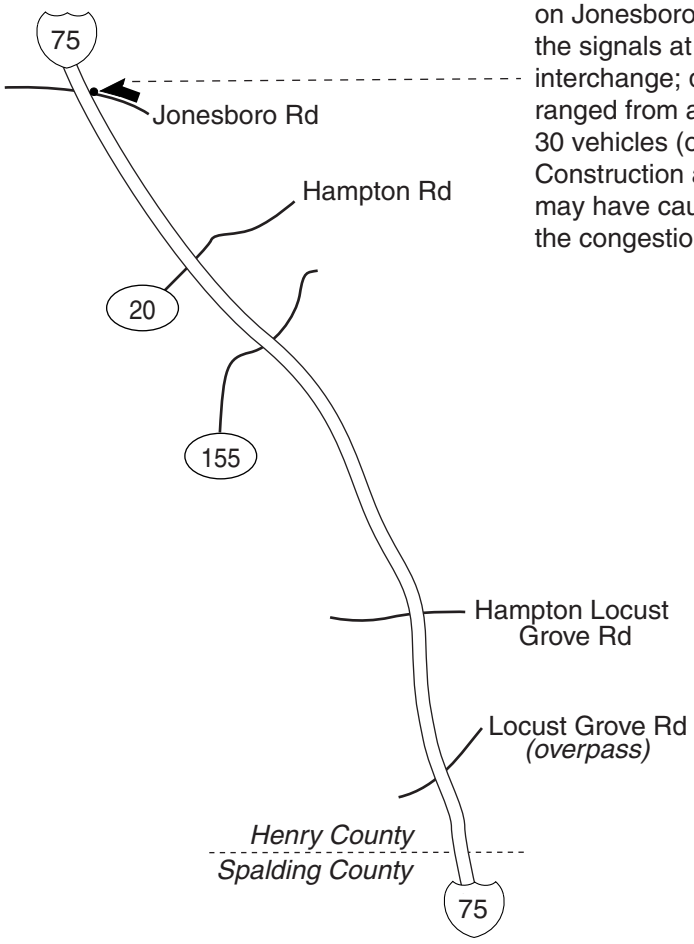
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F		F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

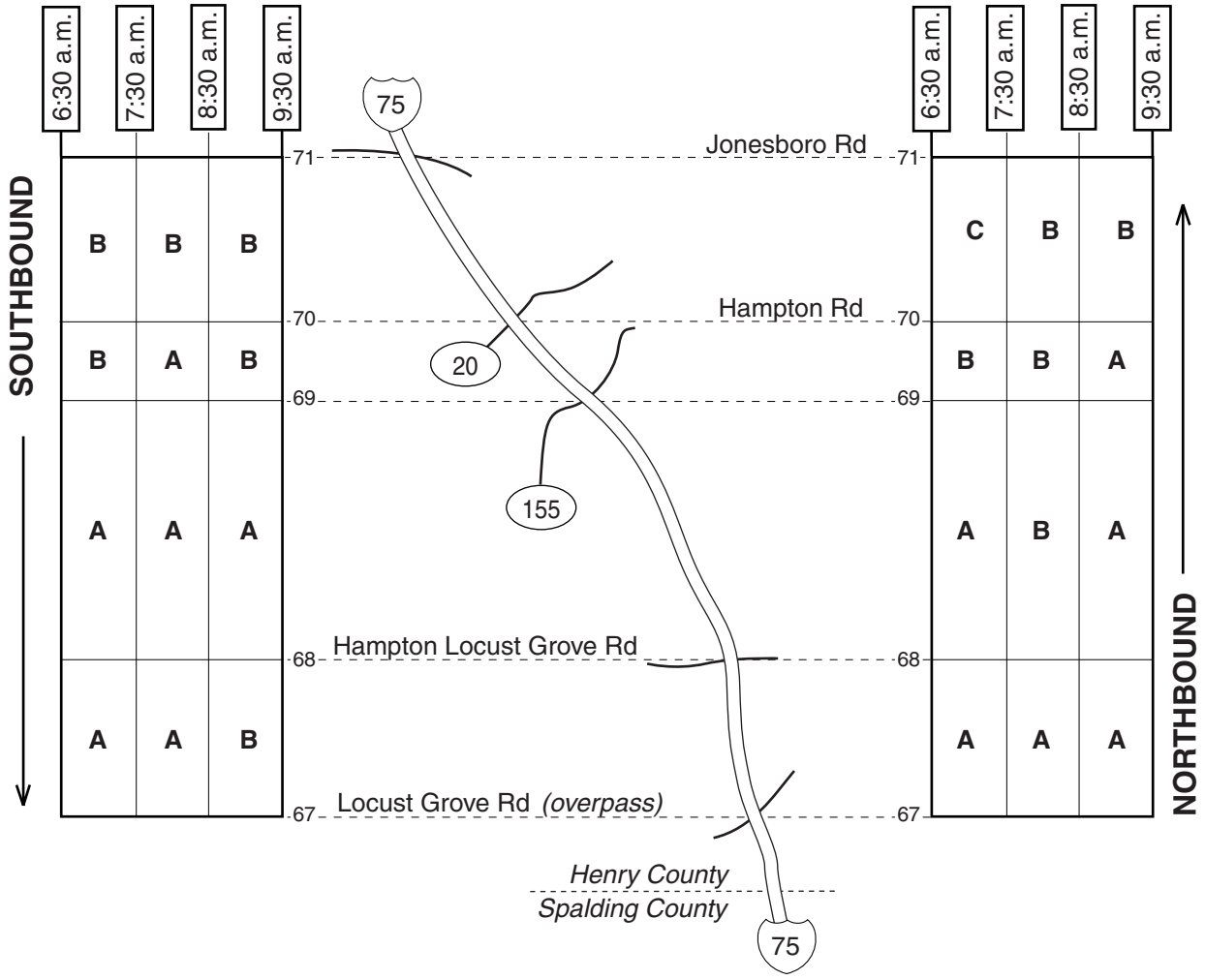
Note: F (60) in the tables means level-of-service "F", with density = 60

I-75 SOUTH
MORNING
(Henry County)



During most observations, westbound congestion was found on Jonesboro Rd approaching the signals at the I-75 interchange; queue populations ranged from approximately 20 to 30 vehicles (one lane). Construction at this interchange may have caused or exacerbated the congestion.

I-75 SOUTH
MORNING
(Henry County)



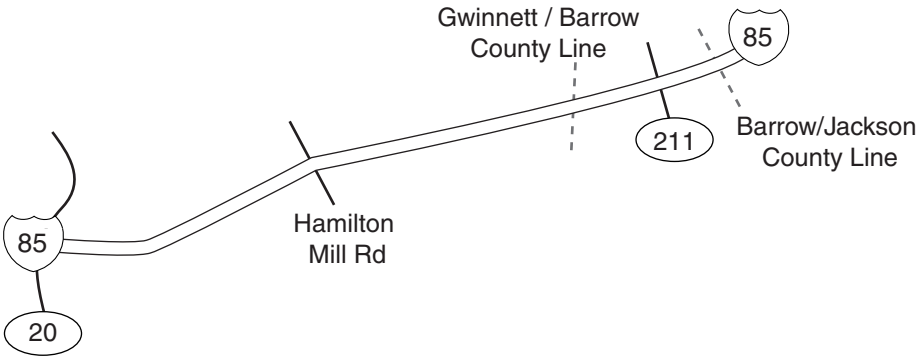
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

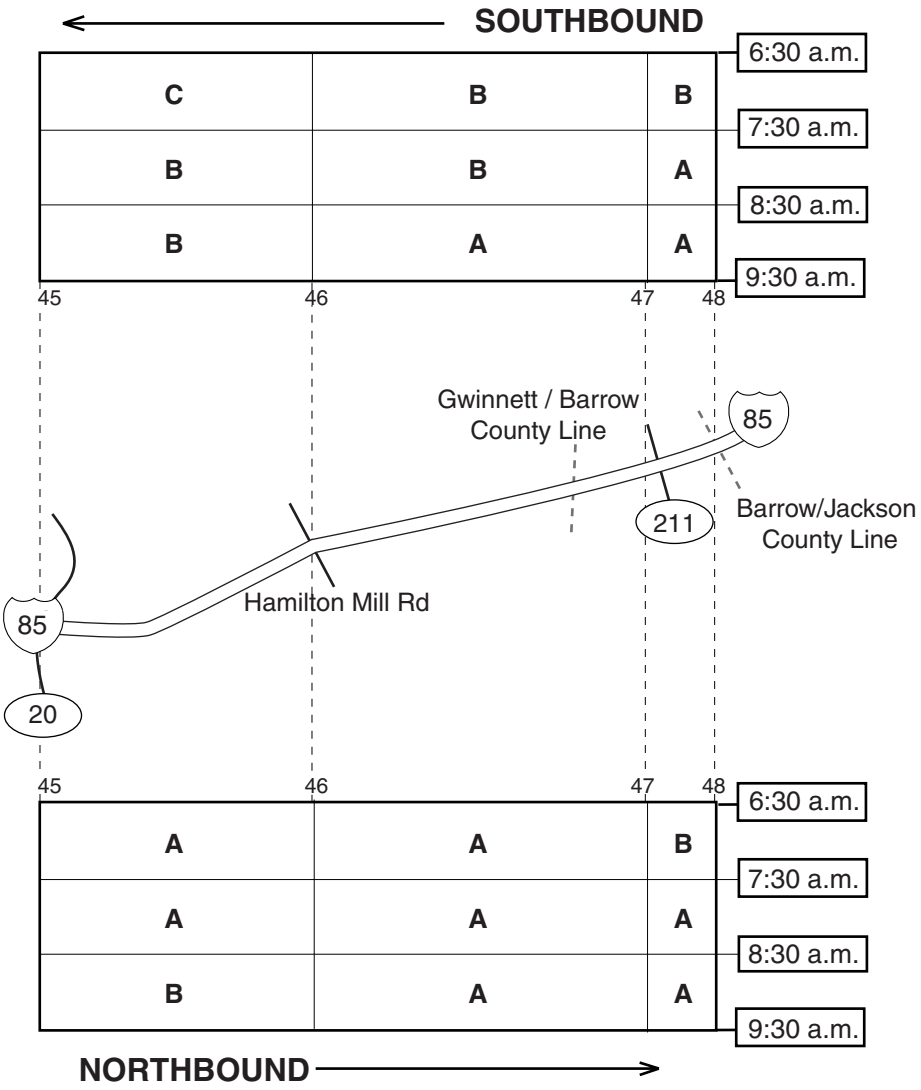
Note: F (60) in the tables means level-of-service "F", with density = 60

I-85 NORTH
MORNING
(Gwinnett / Barrow Counties)



No congestion was found on I-85 (North)
during the morning survey period.

I-85 NORTH
MORNING
(Gwinnett / Barrow Counties)



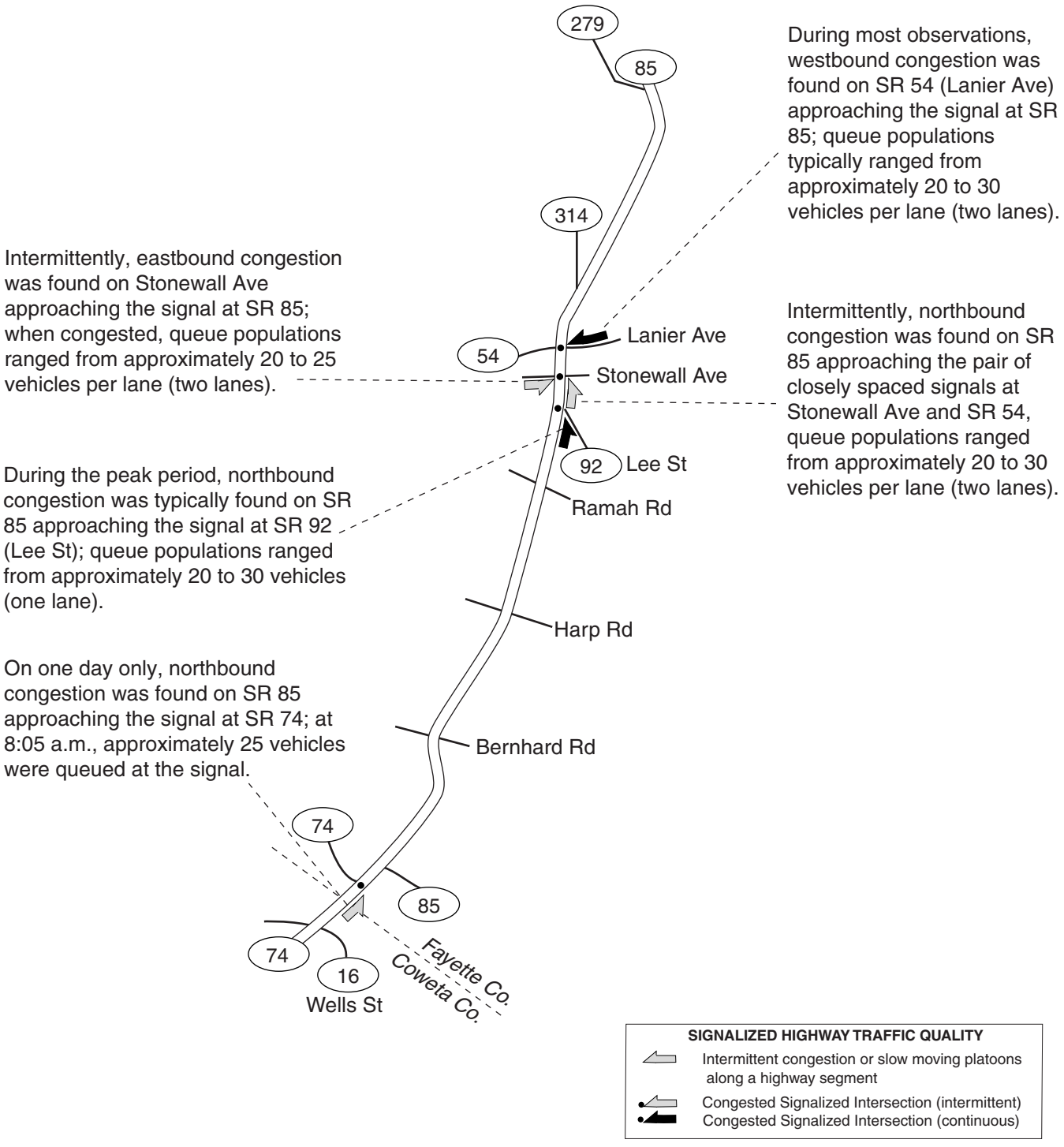
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F		F
0	10	20	30	45	65		

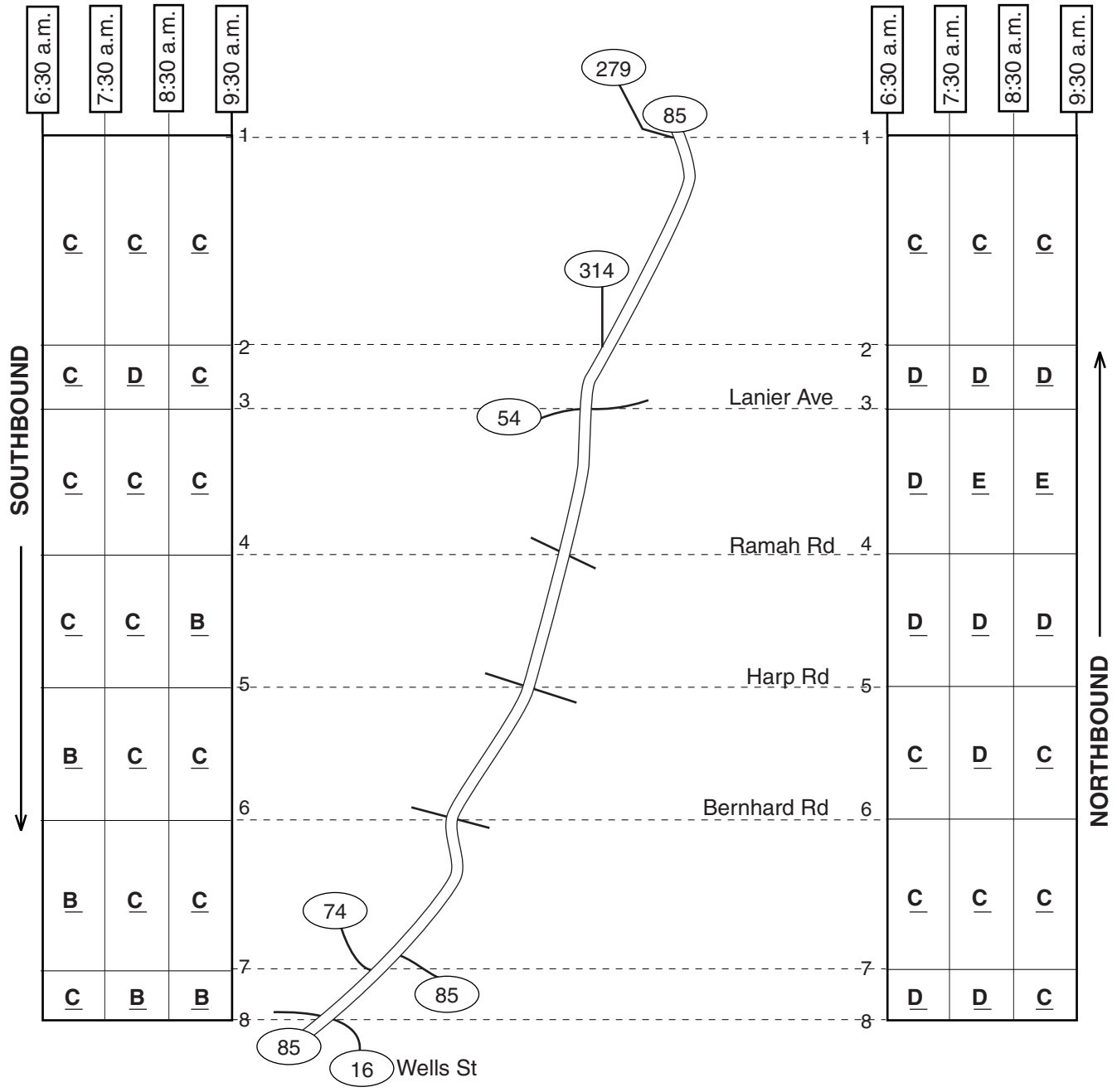
Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

SR 85 SOUTH
MORNING
(Fayette County)



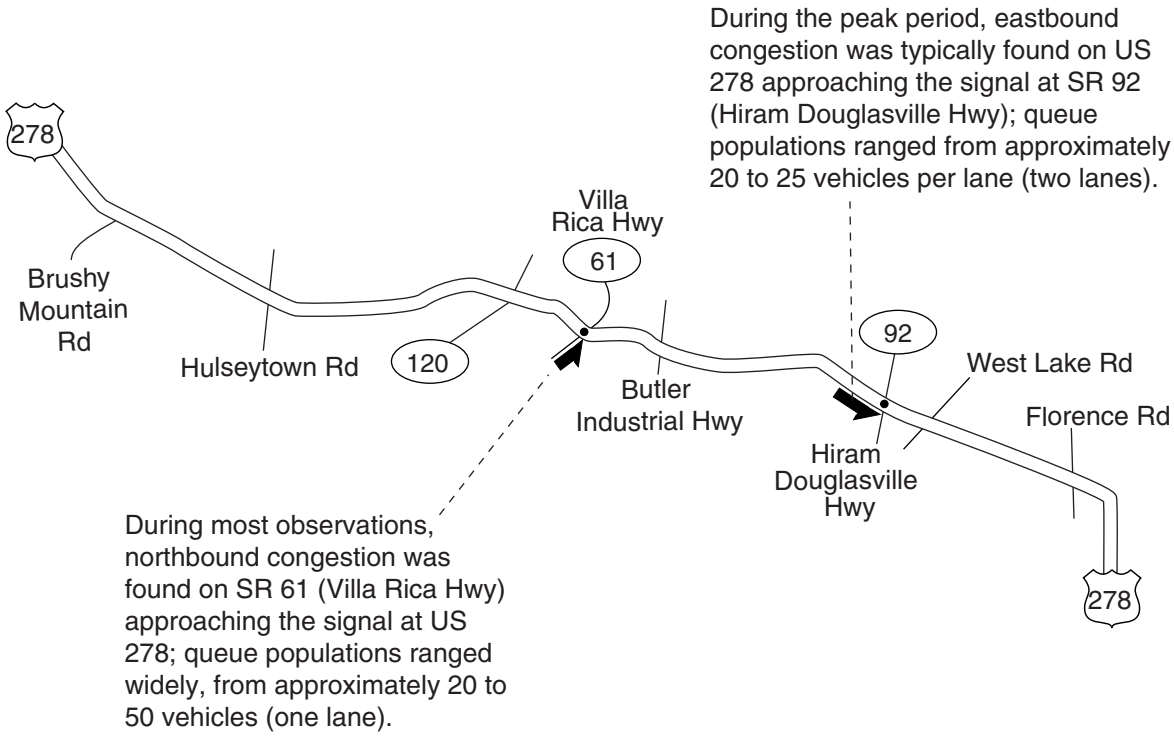
SR 85 SOUTH
MORNING
(Fayette County)



SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

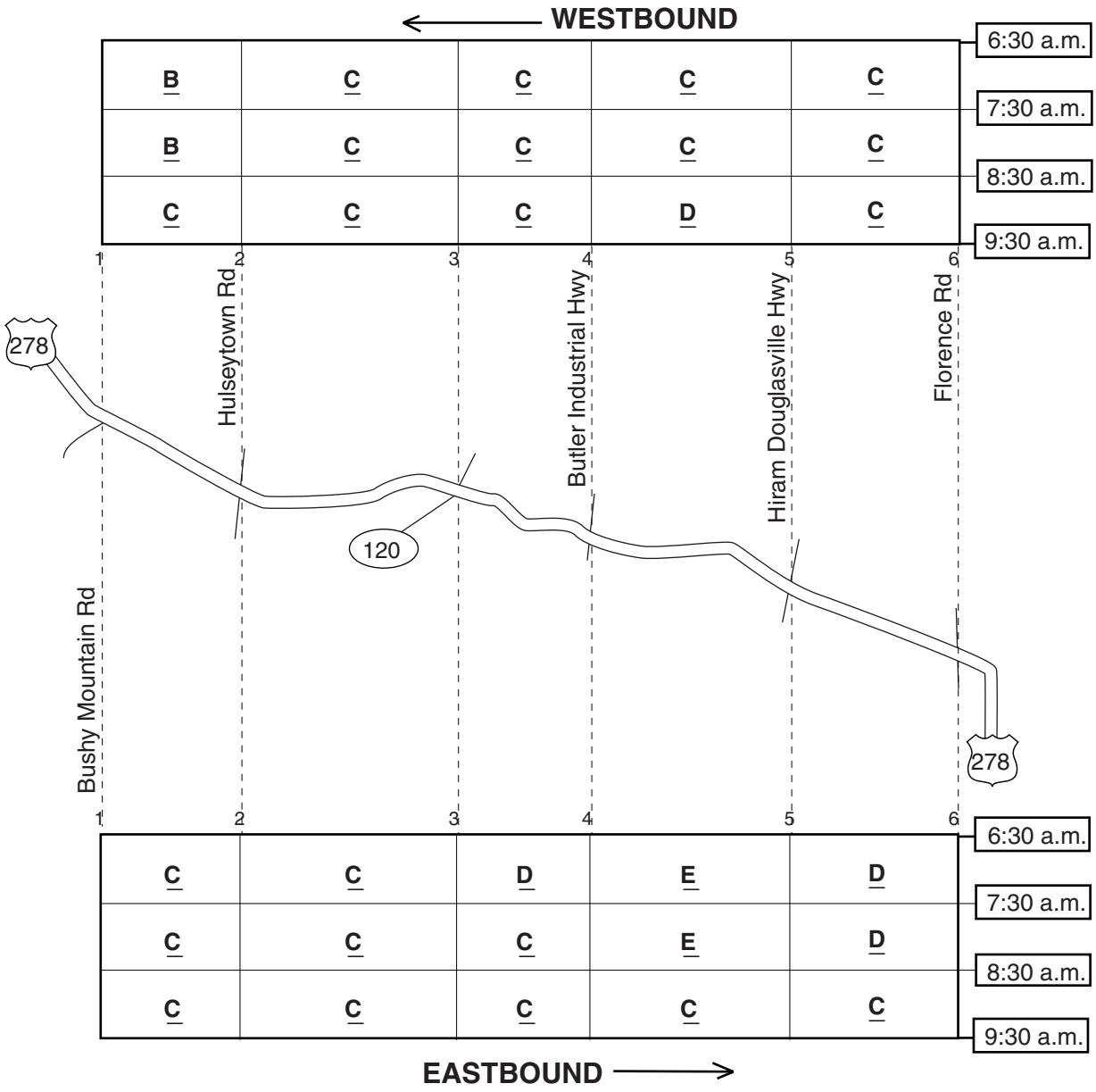
US 278
MORNING
(Cobb / Paulding Counties)



SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

US 278
MORNING
(Cobb / Paulding Counties)



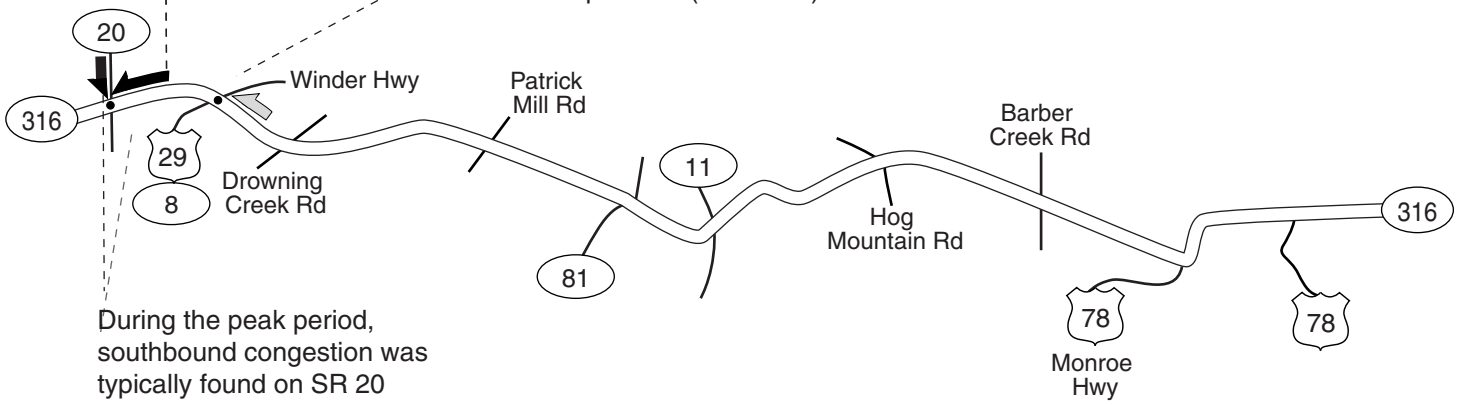
SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

SR 316
MORNING
(Gwinnett / Barrow Counties)

Throughout the morning survey period, westbound congestion was found on SR 316 approaching the signal at SR 20; queue populations ranged widely, from approximately 30 to 85 vehicles per lane (two lanes). After clearing this signal, westbound travelers typically encountered congestion again at the signal at Collins Hill Rd.

During the peak period, westbound congestion was typically found on SR 316 approaching the signal at US Route 29; when congested, queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

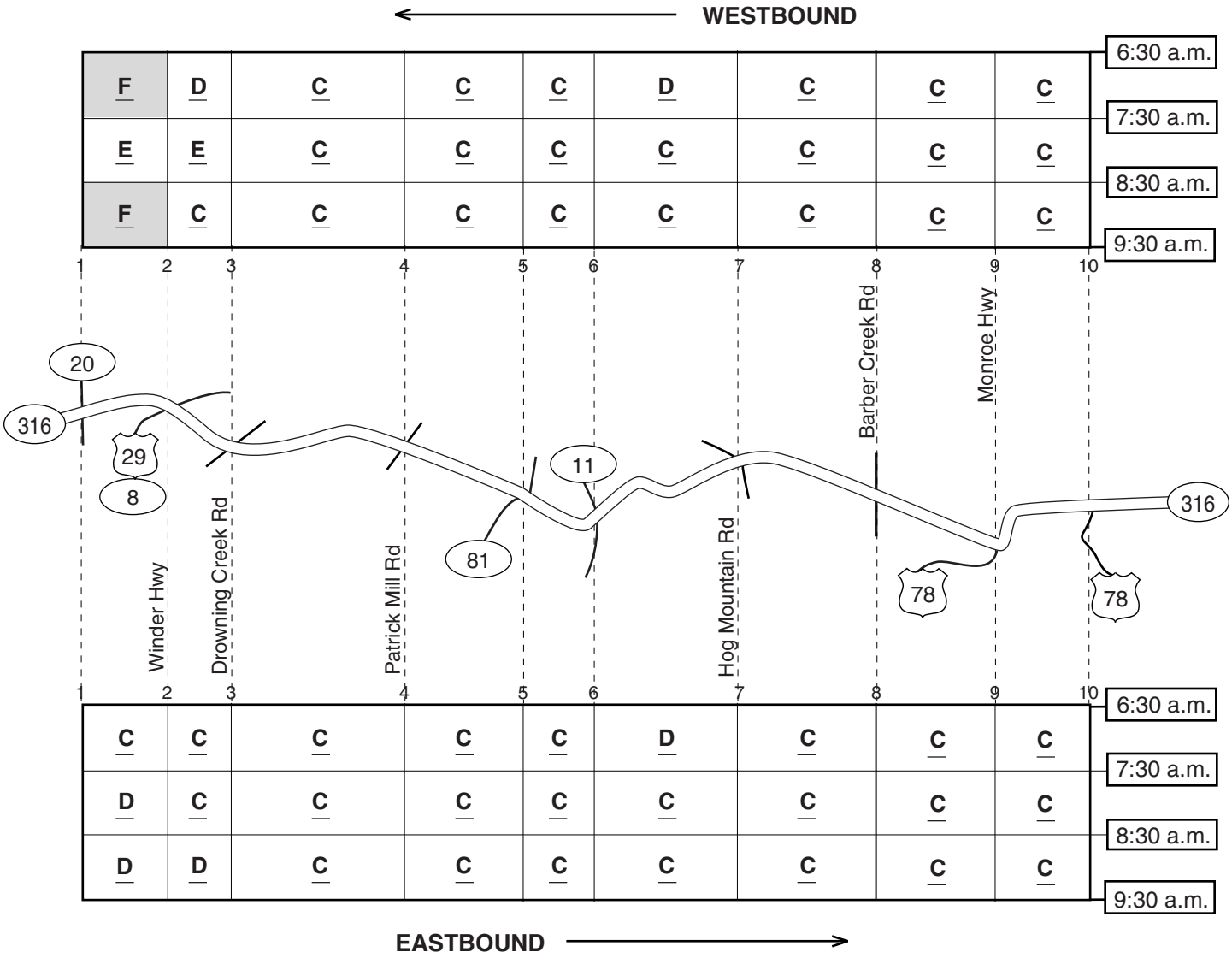


During the peak period, southbound congestion was typically found on SR 20 approaching the signal at SR 316; queue populations ranged widely, from approximately 20 to 50 vehicles per lane (two lanes).

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

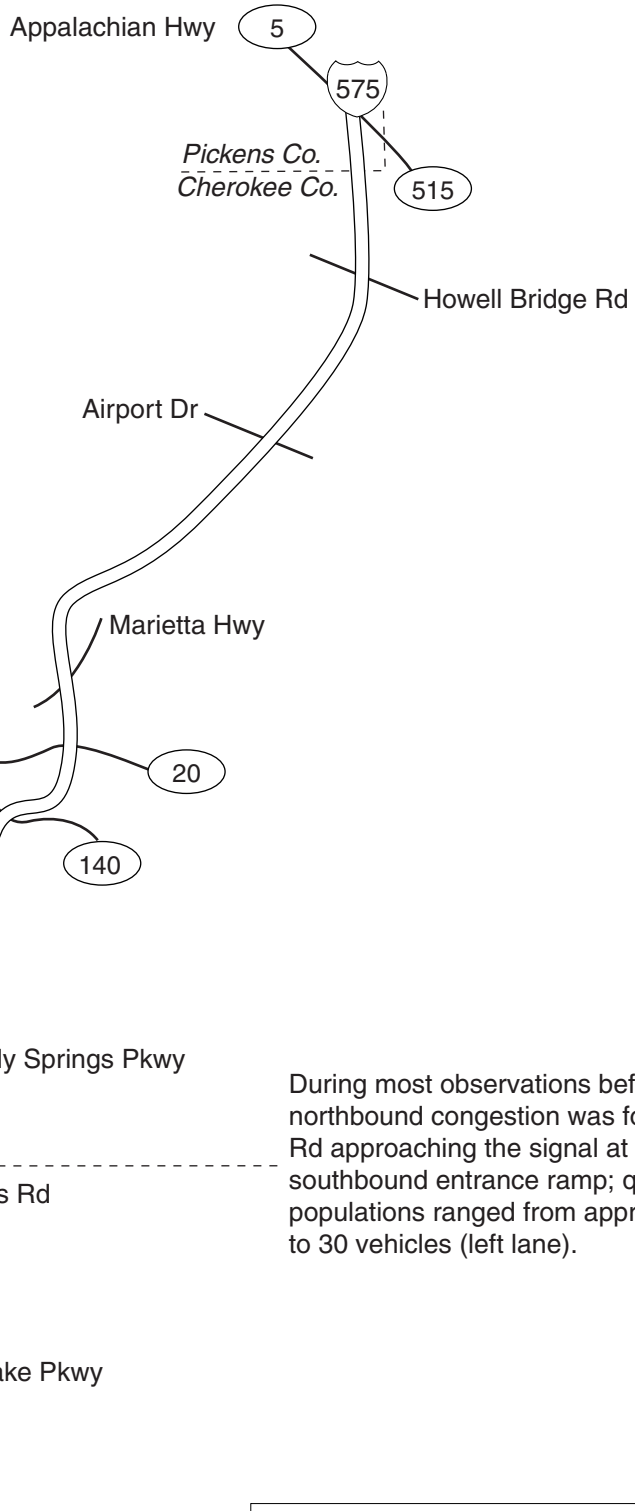
SR 316
MORNING
(Gwinnett / Barrow Counties)



SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

I-575
MORNING
(Cherokee County)



Intermittently, eastbound congestion was found on Towne Lake Pkwy approaching the signal at I-575; when congested, queue populations ranged from approximately 20 to 45 vehicles (left lane/thru-lane). When congested, vehicles in the right lane were able to bypass the queue, and enter the southbound ramp on I-575 without delay.

Early in the survey period (before 7:30 a.m.), a one to two mile zone of southbound congestion was intermittently found on I-575 in the vicinity of Towne Lake Pkwy; traffic entering at Towne Lake Pkwy appeared to cause the congestion.

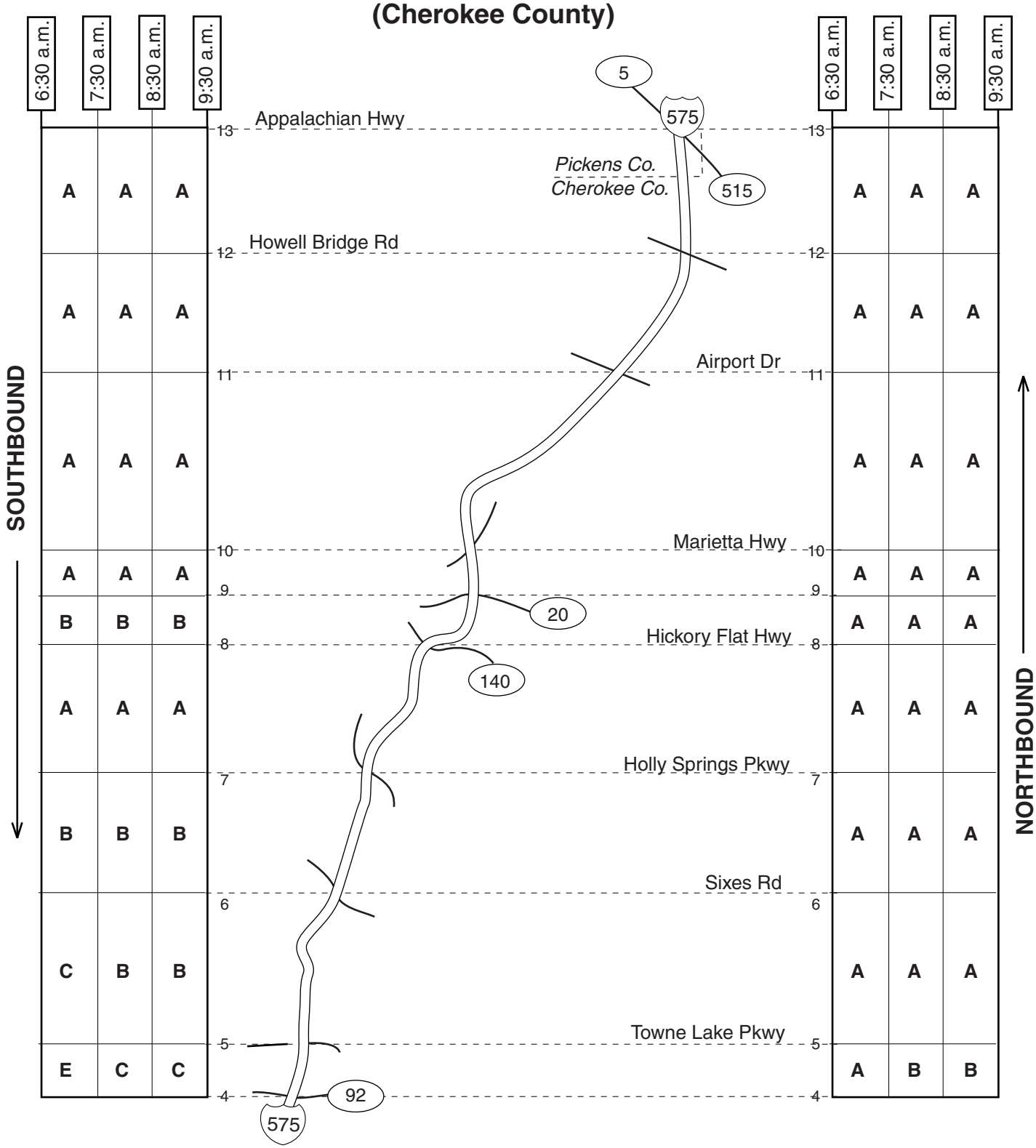
During most observations before 8:00 a.m., northbound congestion was found on Sixes Rd approaching the signal at the I-575 southbound entrance ramp; queue populations ranged from approximately 20 to 30 vehicles (left lane).

HIGHWAY TRAFFIC QUALITY

Congested flow at average speeds of 30-50 mph

Congested flow involving varying degrees of stop-and-go (average speeds < 30 mph)

I-575
MORNING
(Cherokee County)



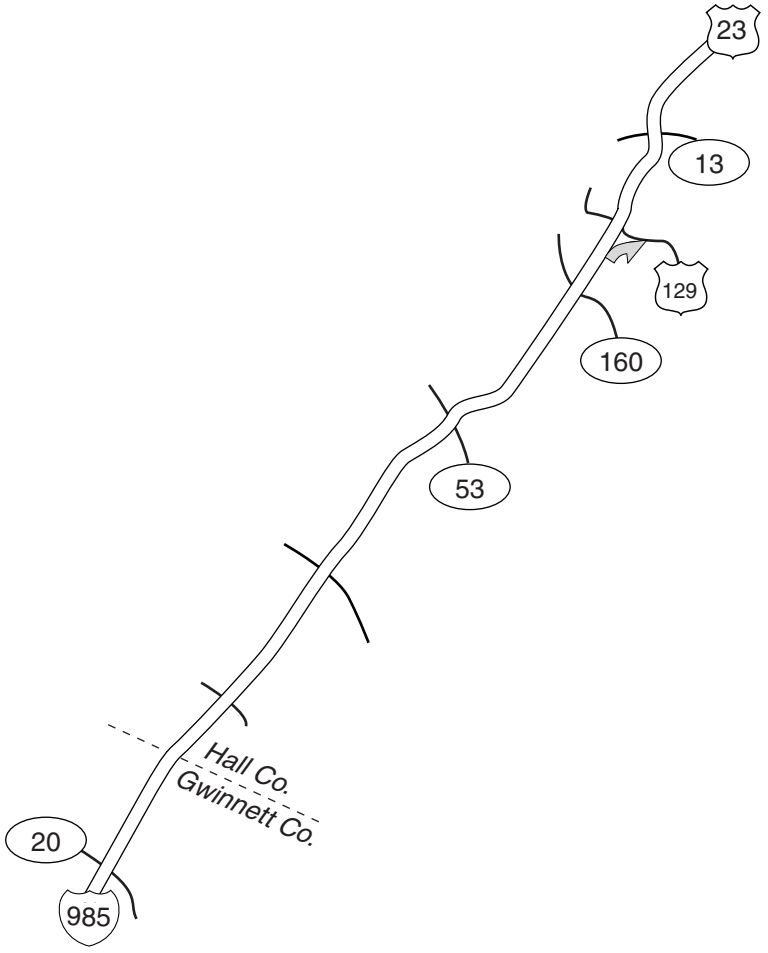
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED		SEVERE
A	B	C	D	E	F		F	
0	10	20	30	45	65			

Density scale (cars per lane-mile)

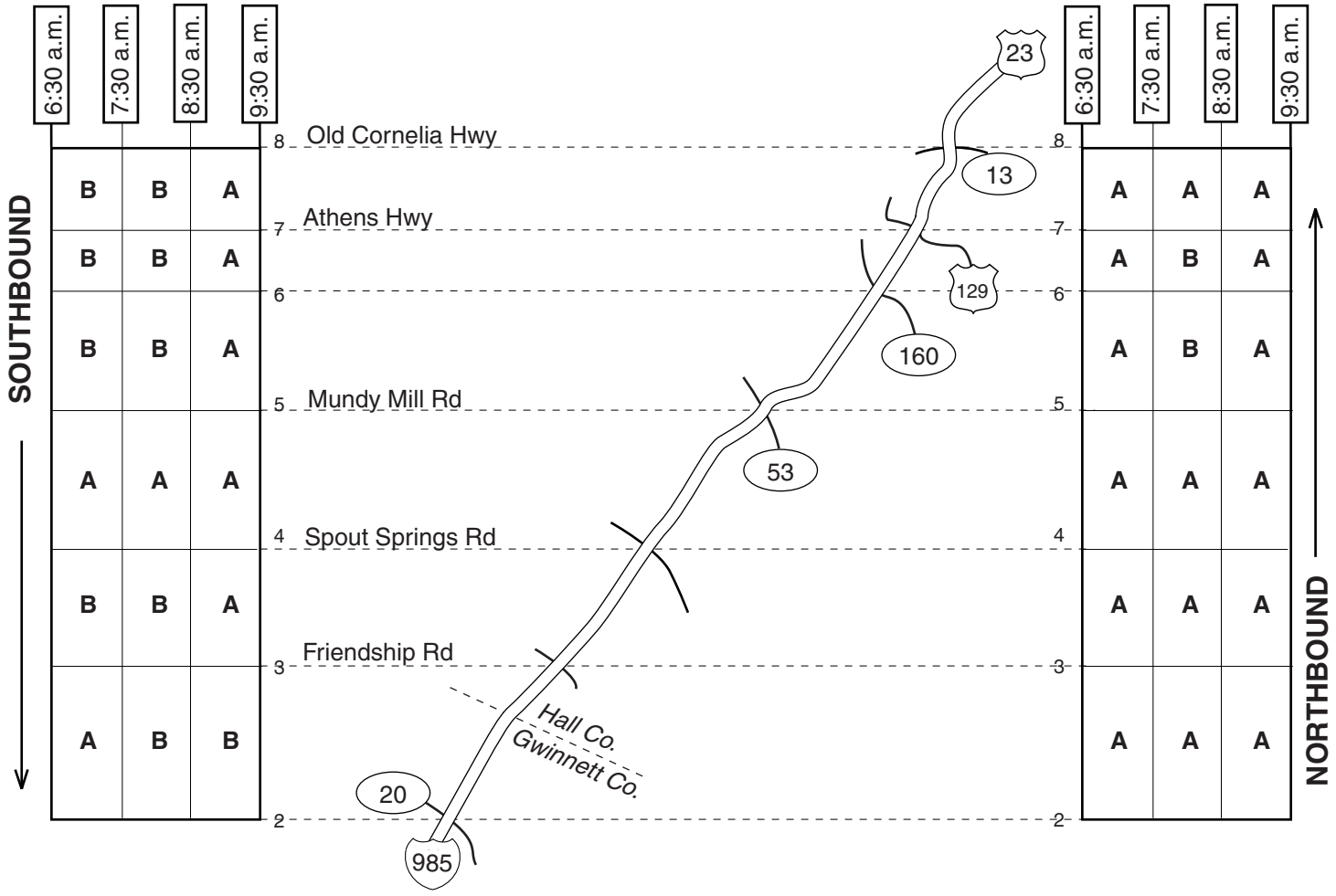
Note: F (60) in the tables means level-of-service "F", with density = 60

I-985
MORNING
(Gwinnett / Hall Counties)



On one day only, congestion was found on the northbound exit ramp at US 129 (Athens Highway); at 7:58 a.m., approximately 30 vehicles were queued at the signal at the head of the ramp.

I-985
MORNING
(Gwinnett / Hall Counties)



LEVEL-OF-SERVICE LEGEND:

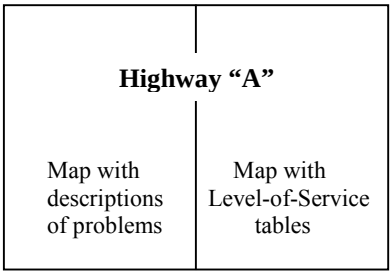
LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

PART TWO

EVENING SURVEY PERIOD



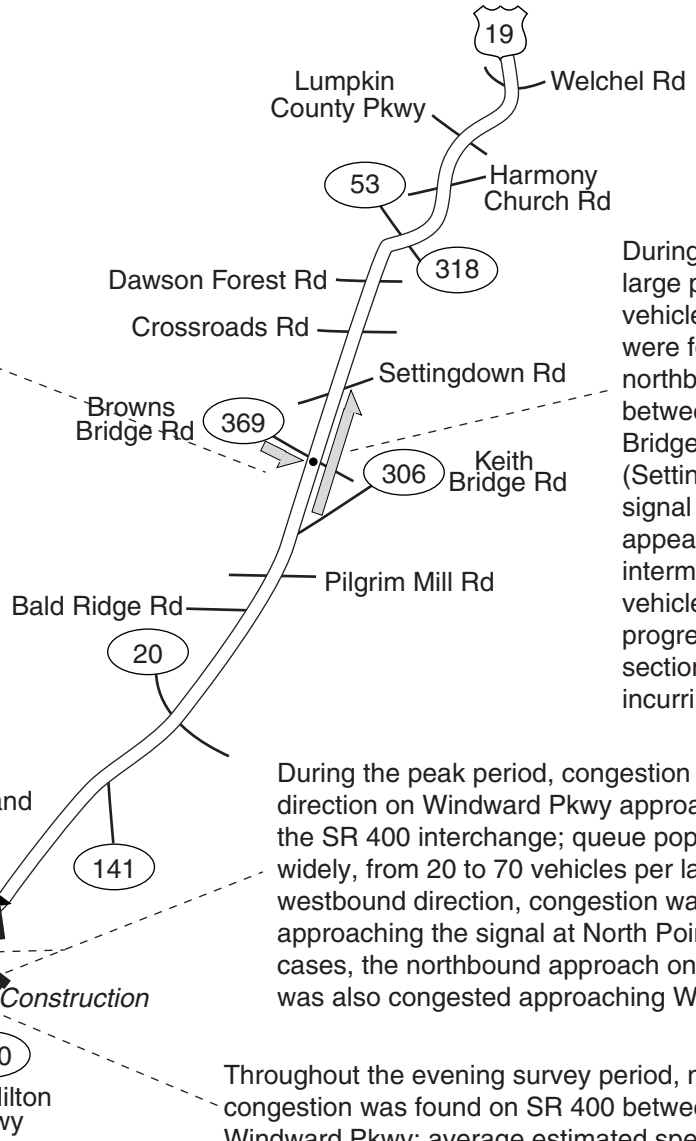
Each highway is presented in a set of opposing maps. The maps with the technical tables on the right contain averaged level-of-service ratings, minus the effects of any known or suspected incidents (actual density values are provided for all LOS "F" ratings). Details are presented in narratives on the left.

Highways are presented in the following order:

- US 19 / SR 400
- US 19/41 (S)
- I-20 (E)
- I-20 (W)
- US 23
- US 41 (N)
- I-75 (N)
- I-75 (S)
- I-85 (N)
- SR 85
- US 278
- SR 316
- I-575
- I-985

Exit numbers for each roadway are assigned by Skycomp, Inc.

US ROUTE 19 / SR 400
EVENING
(Forsyth / Dawson Counties)



During one flyover (4:56 p.m.), eastbound congestion was found on Browns Bridge Rd approaching the signal at US 19; the queue contained 40 vehicles (one lane).

During the peak period, northbound congestion was found on McFarland Rd in the vicinity of the SR 400 interchange; construction on McFarland Rd, west of SR 400 (roadway widening), appeared to cause or exacerbate the congestion.

On some days and not others, southbound congestion was found on SR 400 between Windward Pkwy and SR 120; when congested, average estimated speeds ranged from approximately 40 to 50 mph.

Intermittently, eastbound congestion was found on SR 120 approaching the signal (southbound entrance ramp) at SR 400; queue populations ranged from approximately 20 to 40 vehicles per lane (two lanes).

During most observations, large platoons (25 to 35 vehicles per lane; two lanes) were found traveling northbound on US 19 between SR 306 (Keith Bridge Rd) and SR 369 (Settingdown Rd); while the signal at Browns Bridge Rd appeared to generate intermittent congestion, vehicles appeared to progress steadily along this section of US 19 without incurring major delay.

During the peak period, congestion was found in each direction on Windward Pkwy approaching the signals at the SR 400 interchange; queue populations ranged widely, from 20 to 70 vehicles per lane (two lanes). In the westbound direction, congestion was also found approaching the signal at North Point Pkwy; in some cases, the northbound approach on North Point Pkwy was also congested approaching Windward Parkway.

Throughout the evening survey period, northbound congestion was found on SR 400 between SR 120 and Windward Pkwy; average estimated speeds ranged from approximately 30 to 50 mph. The head of the queue was found at the construction zone at Windward Pkwy.

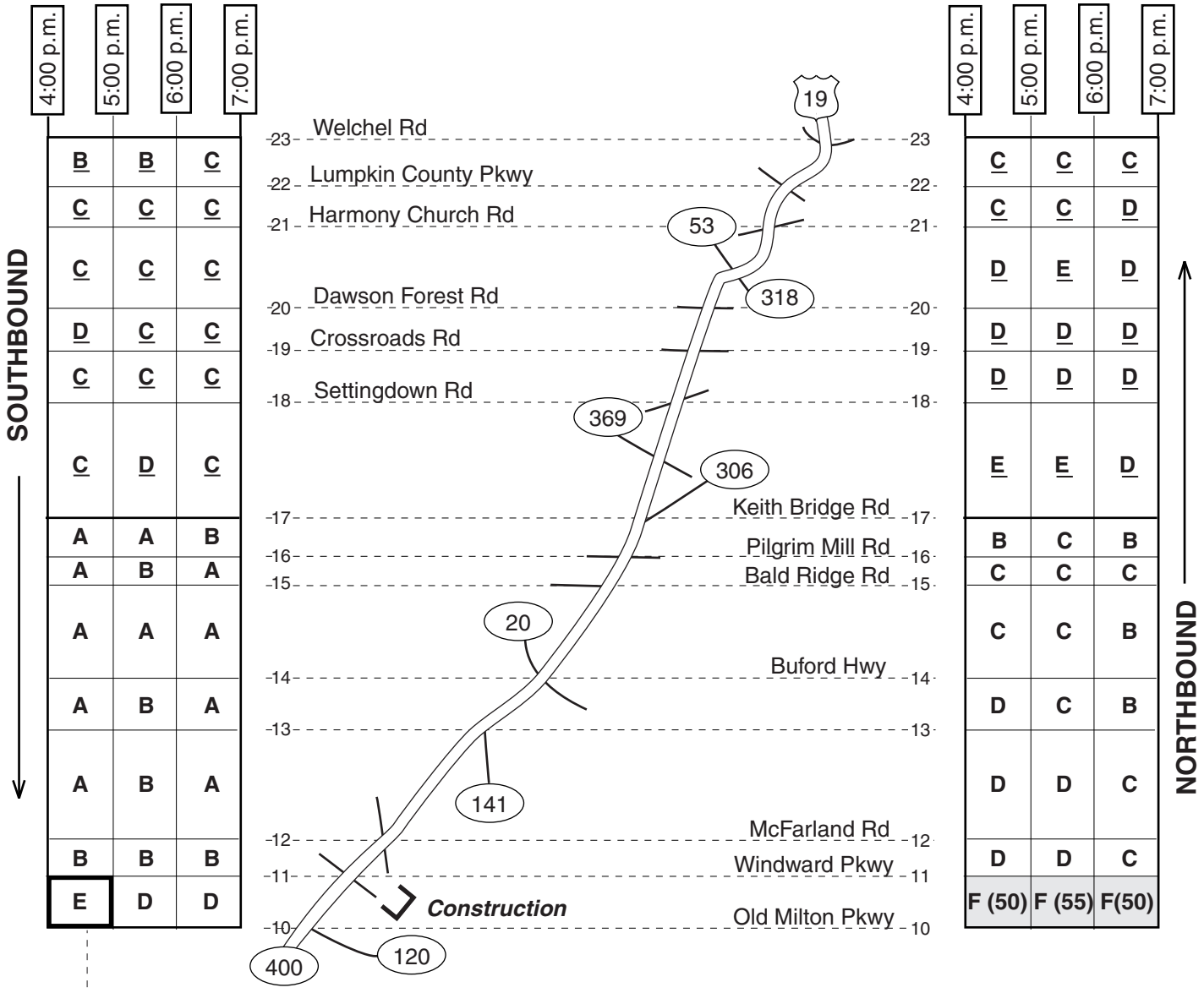
HIGHWAY TRAFFIC QUALITY

- Congested flow at average speeds of 30-50 mph
- Congested flow involving varying degrees of stop-and-go (average speeds < 30 mph)

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested Signalized Intersection (intermittent)
- Congested Signalized Intersection (continuous)

US ROUTE 19 / SR 400
EVENING
(Forsyth / Dawson Counties)



This level-of-service rating represents the mathematical average of densities, which varied from day-to-day (congested, not congested); when congested, densities typically ranged from approximately 60 to 45 pcplpm with corresponding speeds estimated at 35 to 50 mph.

SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

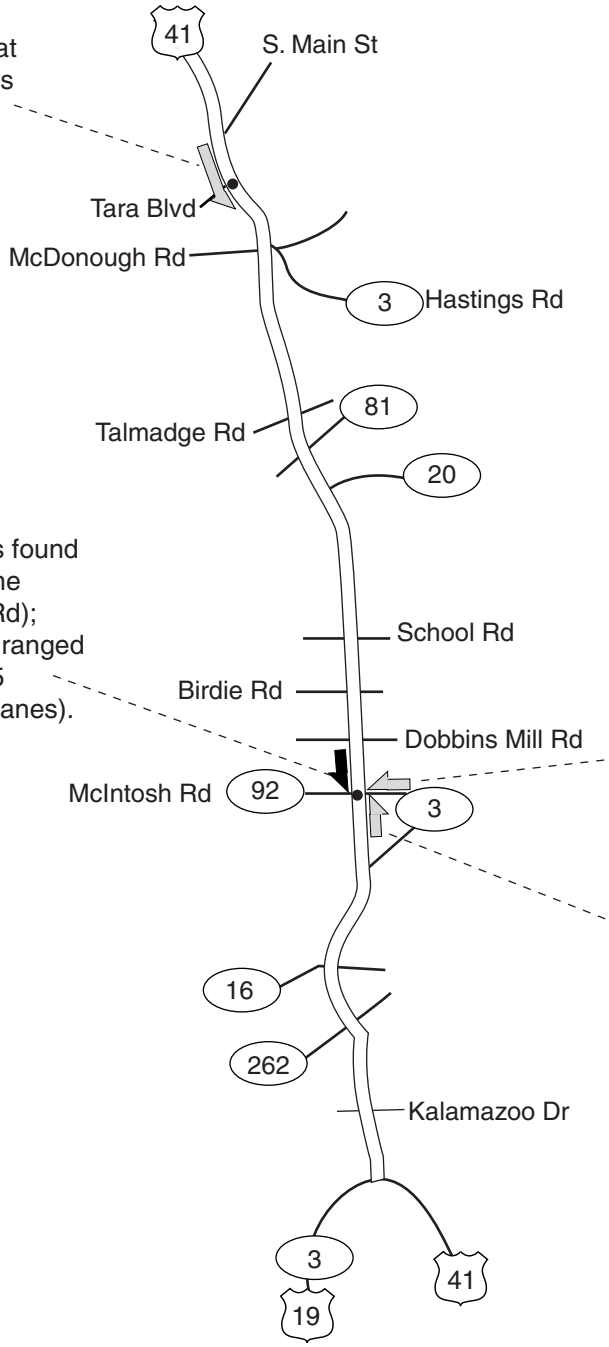
US 19/41 SOUTH
EVENING
(Clayton / Henry / Spalding Counties)

During most observations, large southbound platoons were found on US 19/41 traveling through the signal at Tara Blvd; while some delays were apparent, significant queue populations were not found at this signal.

During most observations, southbound congestion was found on US 19/41 approaching the signal at SR 92 (McIntosh Rd); queue populations typically ranged from approximately 20 to 35 vehicles per lane (two thru-lanes).

During the peak period, westbound congestion was typically found on SR 92 approaching the signal at US 19/41; when congested, queue populations ranged from approximately 20 to 30 vehicles (one lane).

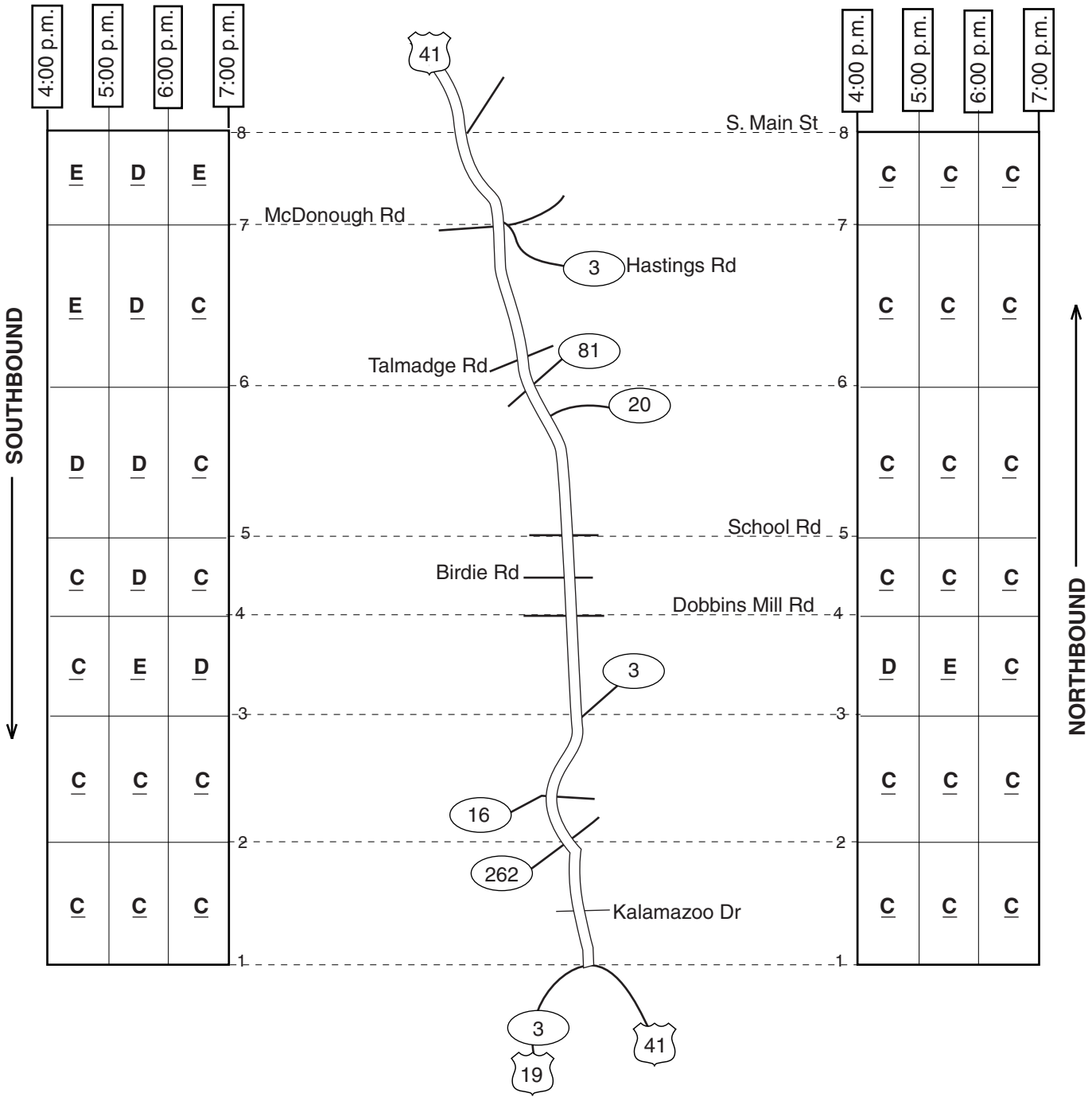
During the peak period, intermittent northbound congestion was found on US 19/41 approaching the signal at SR 92 (McIntosh Rd); when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two thru-lanes).



SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

US 19/41 SOUTH
EVENING
(Clayton / Henry / Spalding Counties)

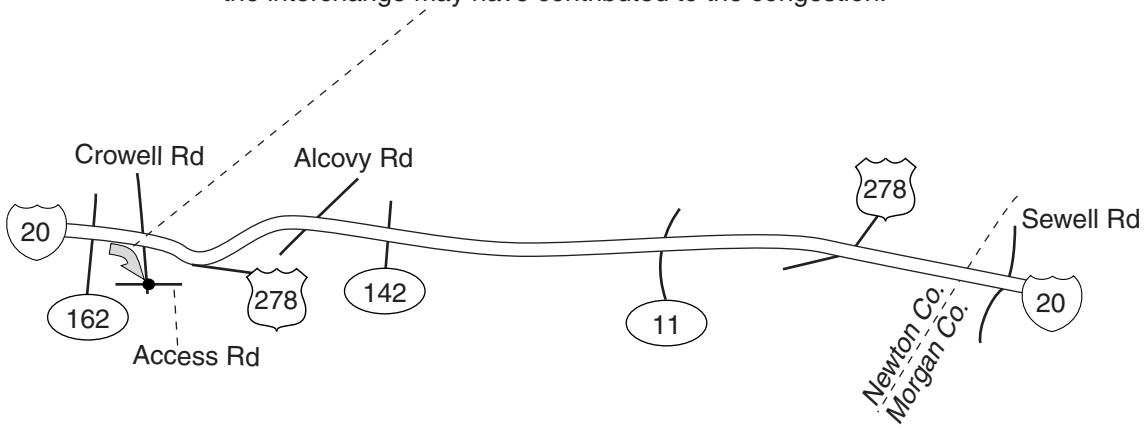


SURROGATE LEVEL-OF-SERVICE LEGEND:

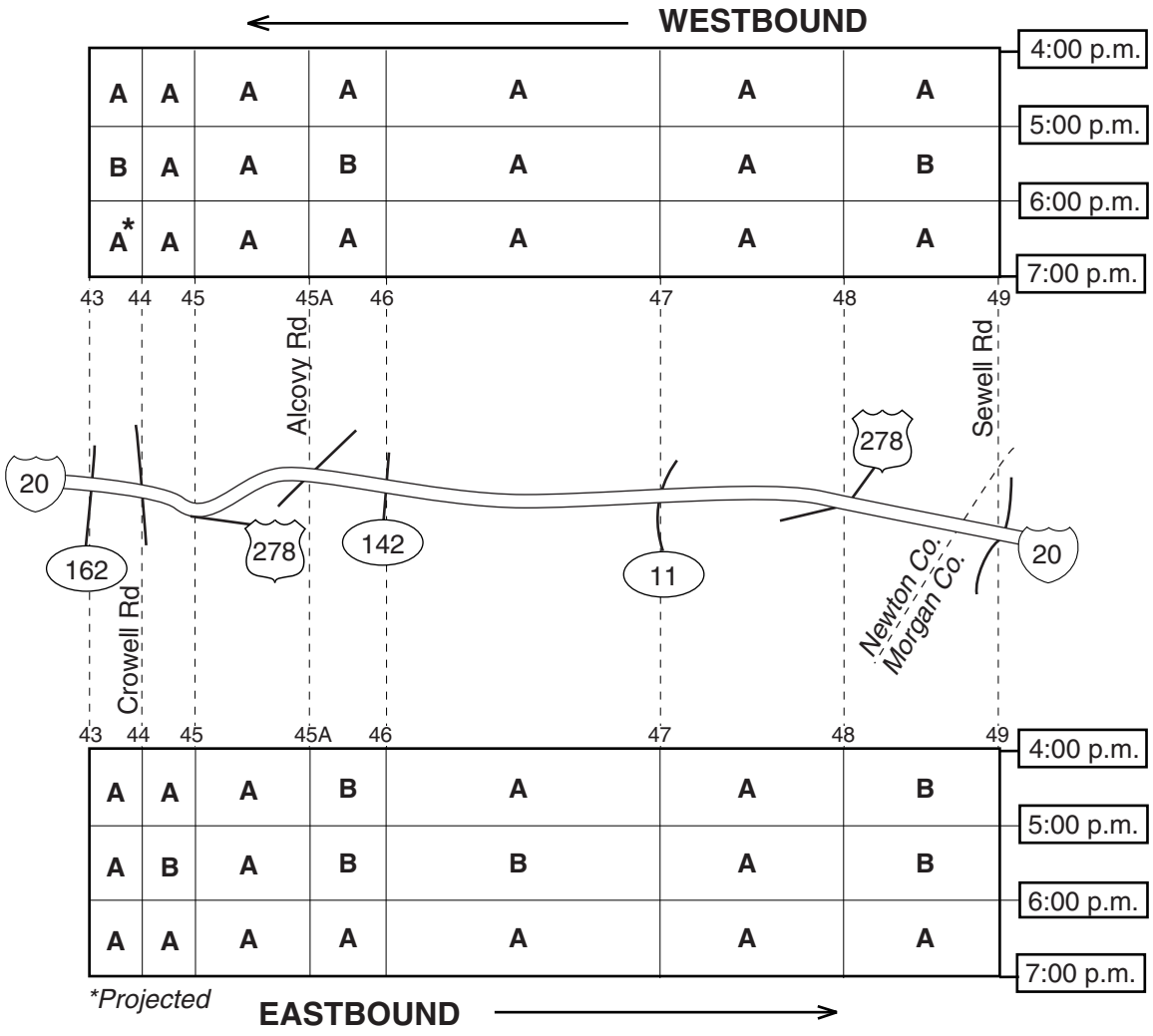
LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

I-20 EAST
EVENING
(Newton County)

On one day only, congestion was found on the eastbound exit ramp at Crowell Rd; at 5:52 p.m., approximately 35 vehicles were queued on the ramp (one lane). The head of the queue was found at the signal on the frontage road (Access Rd). Construction at the interchange may have contributed to the congestion.



I-20 EAST
EVENING
(Newton County)



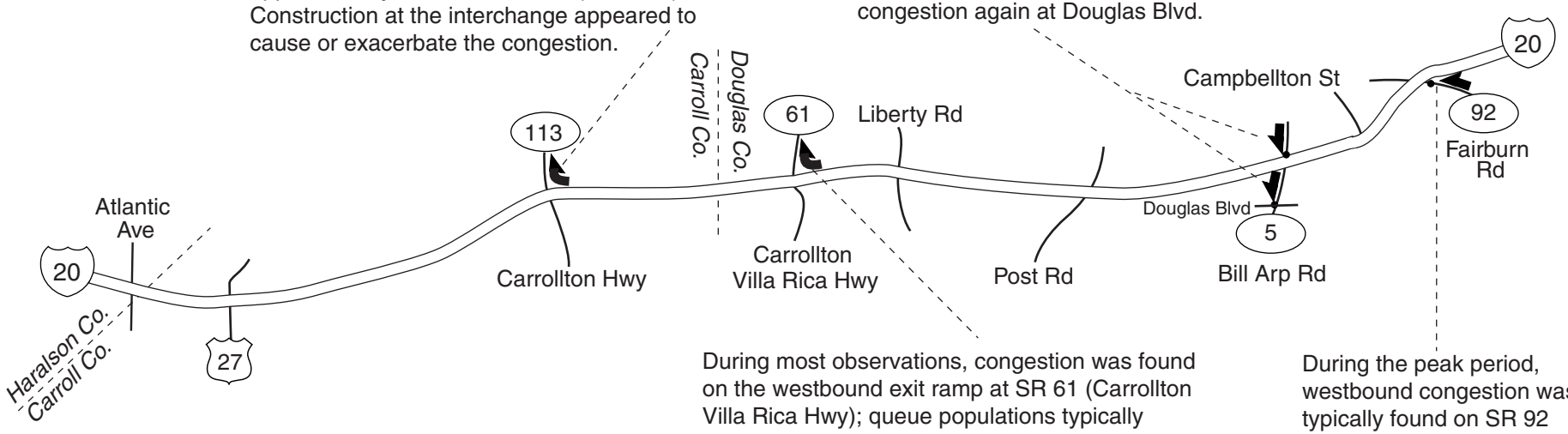
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

I-20 WEST
EVENING
(Carroll / Douglas Counties)



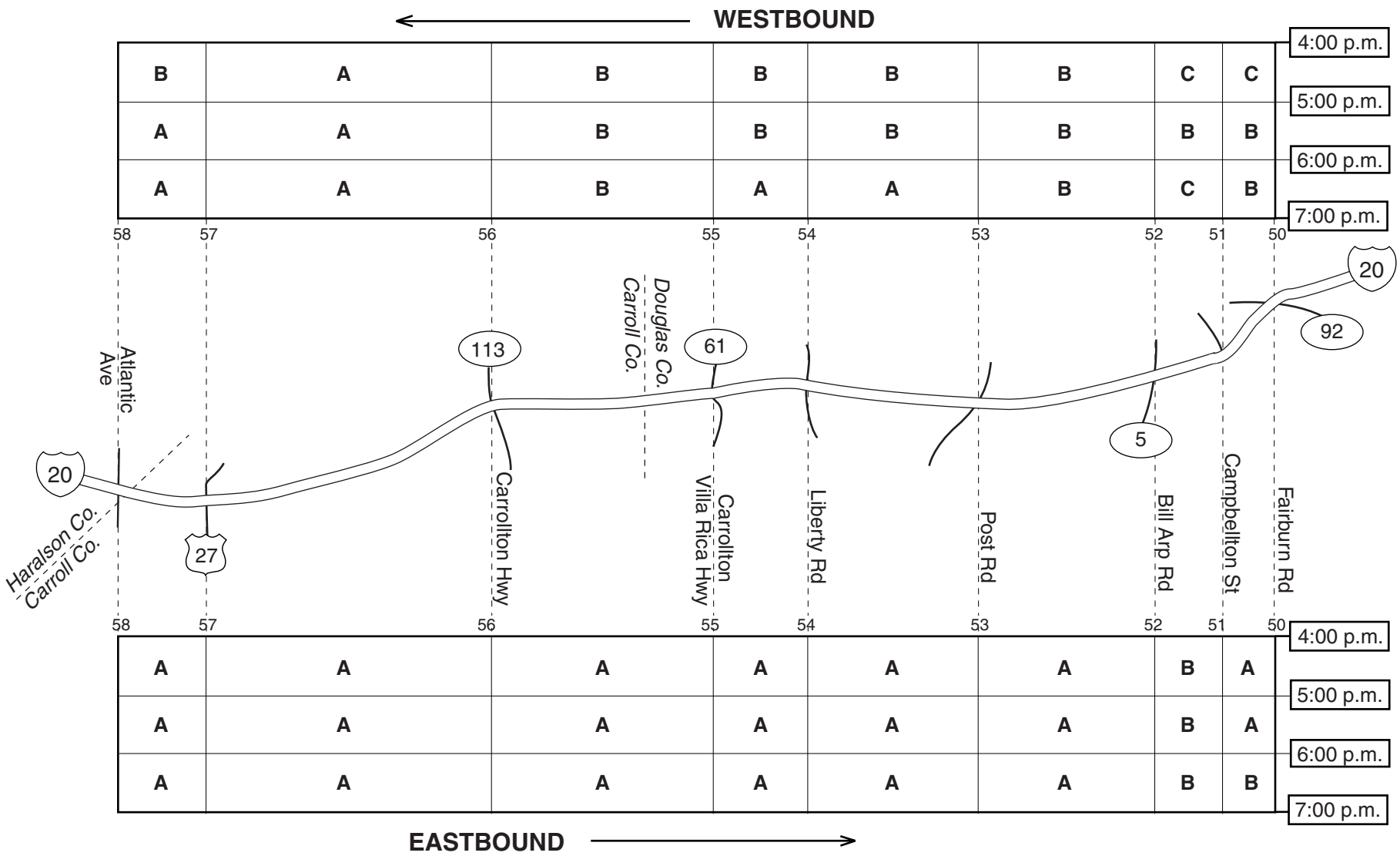
During most observations, congestion was found on the westbound exit ramp at SR 113 (Carrollton Hwy); queue populations typically ranged from approximately 20 to 40 vehicles (one lane). Construction at the interchange appeared to cause or exacerbate the congestion.

During the peak period, southbound congestion was found on SR 5 (Bill Arp Rd) approaching the signals at the I-20 interchange; after clearing these signals, thru traffic typically encountered congestion again at Douglas Blvd.

During most observations, congestion was found on the westbound exit ramp at SR 61 (Carrollton Villa Rica Hwy); queue populations typically ranged from approximately 20 to 40 vehicles (one lane). Construction at the interchange appeared to cause or exacerbate the congestion.

During the peak period, westbound congestion was typically found on SR 92 approaching the series of signals at the I-20 interchange; queue populations typically ranged from approximately 20 to 30 vehicles per lane (two lanes).

I-20 WEST
EVENING
(Carroll / Douglas Counties)



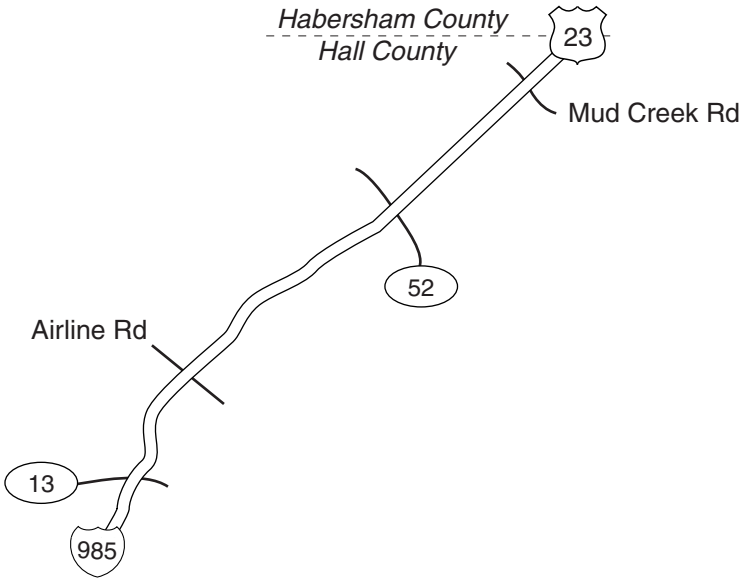
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F		F
0	10	20	30	45	65		

Density scale (cars per lane-mile)

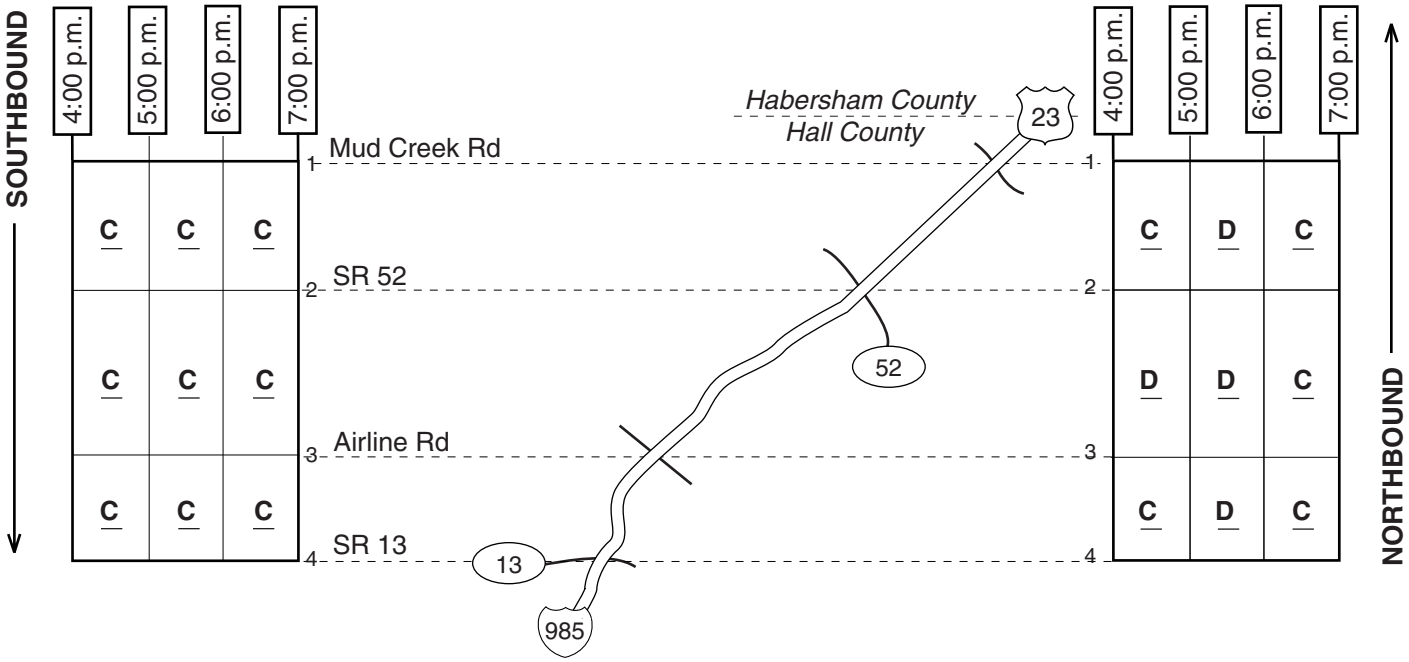
Note: F (60) in the tables means level-of-service "F", with density = 60

US 23
EVENING
(Hall County)



No congestion was found on US Route 23 during the evening survey period; however, during the peak period, platoon populations ranging from 15 to 25 vehicles per lane were typically found traveling northbound between SR 13 and the Habersham County Line.

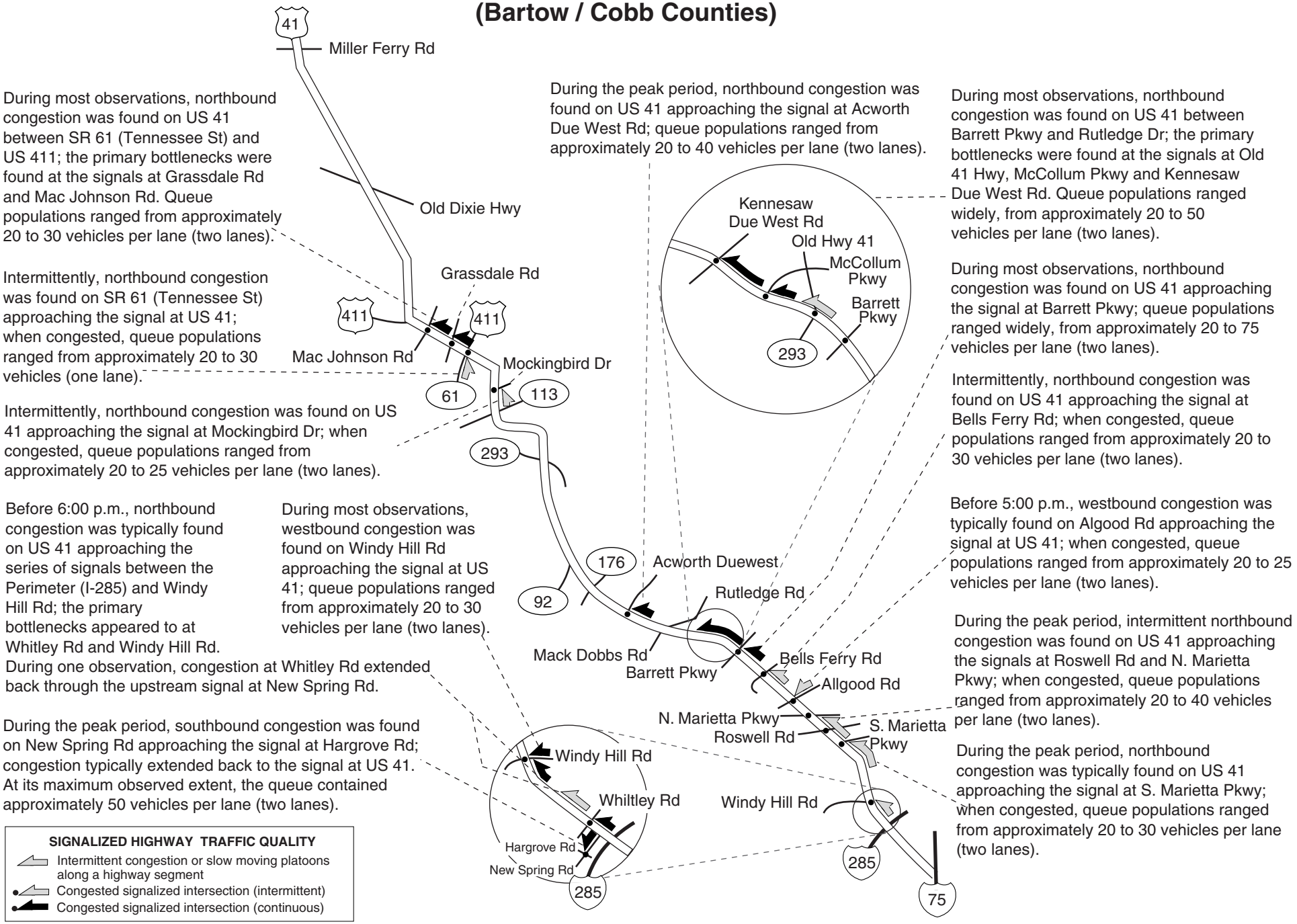
US 23
EVENING
(Hall County)



SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

US 41 NORTH
EVENING
(Bartow / Cobb Counties)



During most observations, northbound congestion was found on US 41 between SR 61 (Tennessee St) and US 411; the primary bottlenecks were found at the signals at Grassdale Rd and Mac Johnson Rd. Queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

Intermittently, northbound congestion was found on SR 61 (Tennessee St) approaching the signal at US 41; when congested, queue populations ranged from approximately 20 to 30 vehicles (one lane).

Intermittently, northbound congestion was found on US 41 approaching the signal at Mockingbird Dr; when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two lanes).

Before 6:00 p.m., northbound congestion was typically found on US 41 approaching the series of signals between the Perimeter (I-285) and Windy Hill Rd; the primary bottlenecks appeared to at Whitley Rd and Windy Hill Rd. During one observation, congestion at Whitley Rd extended back through the upstream signal at New Spring Rd.

During most observations, westbound congestion was found on Windy Hill Rd approaching the signal at US 41; queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

During the peak period, southbound congestion was found on New Spring Rd approaching the signal at Hargrove Rd; congestion typically extended back to the signal at US 41. At its maximum observed extent, the queue contained approximately 50 vehicles per lane (two lanes).

During the peak period, northbound congestion was found on US 41 approaching the signal at Acworth Due West Rd; queue populations ranged from approximately 20 to 40 vehicles per lane (two lanes).

During most observations, northbound congestion was found on US 41 between Barrett Pkwy and Rutledge Dr; the primary bottlenecks were found at the signals at Old 41 Hwy, McCollum Pkwy and Kennesaw Due West Rd. Queue populations ranged widely, from approximately 20 to 50 vehicles per lane (two lanes).

During most observations, northbound congestion was found on US 41 approaching the signal at Barrett Pkwy; queue populations ranged widely, from approximately 20 to 75 vehicles per lane (two lanes).

Intermittently, northbound congestion was found on US 41 approaching the signal at Bells Ferry Rd; when congested, queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

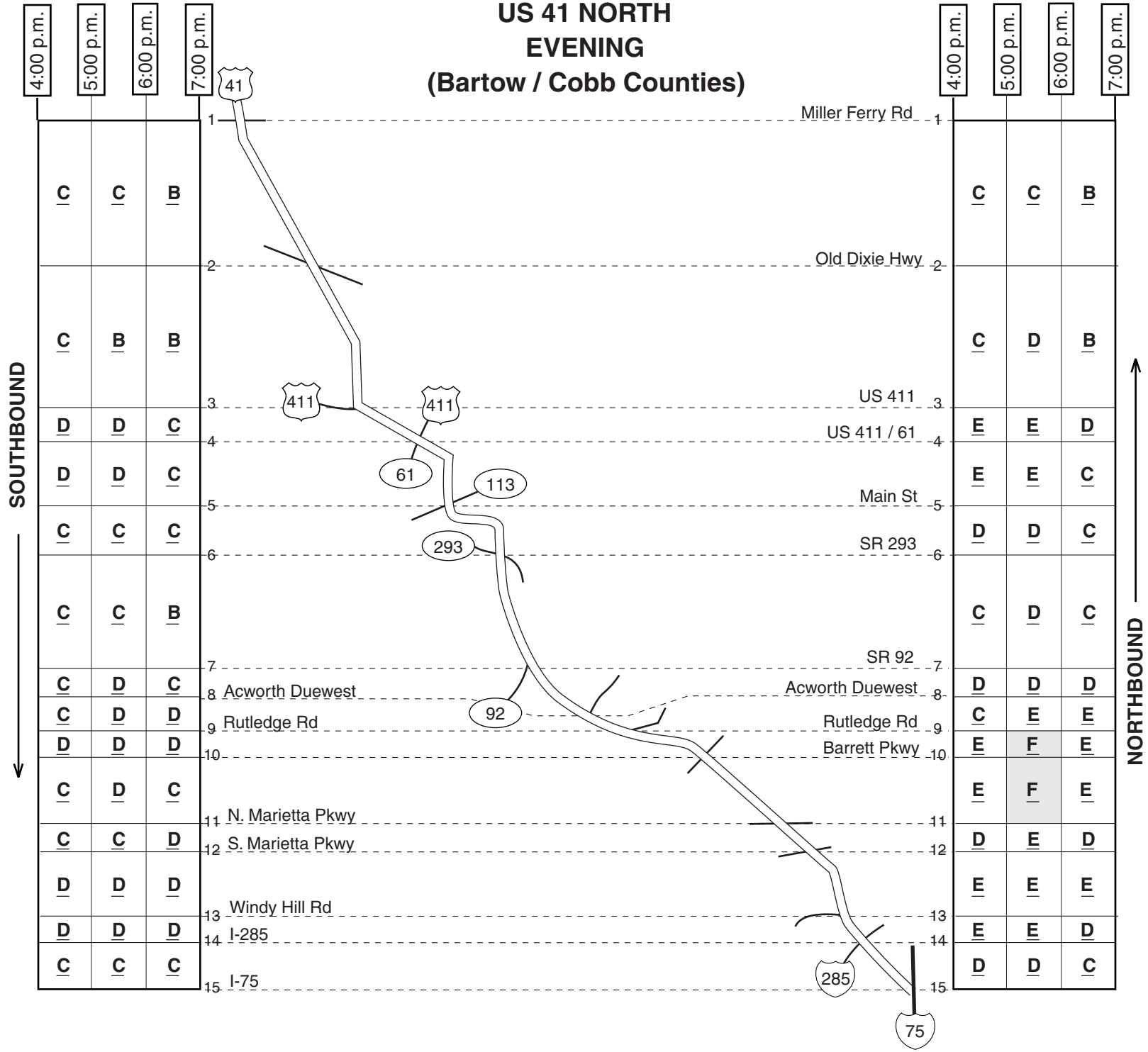
Before 5:00 p.m., westbound congestion was typically found on Algood Rd approaching the signal at US 41; when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two lanes).

During the peak period, intermittent northbound congestion was found on US 41 approaching the signals at Roswell Rd and N. Marietta Pkwy; when congested, queue populations ranged from approximately 20 to 40 vehicles per lane (two lanes).

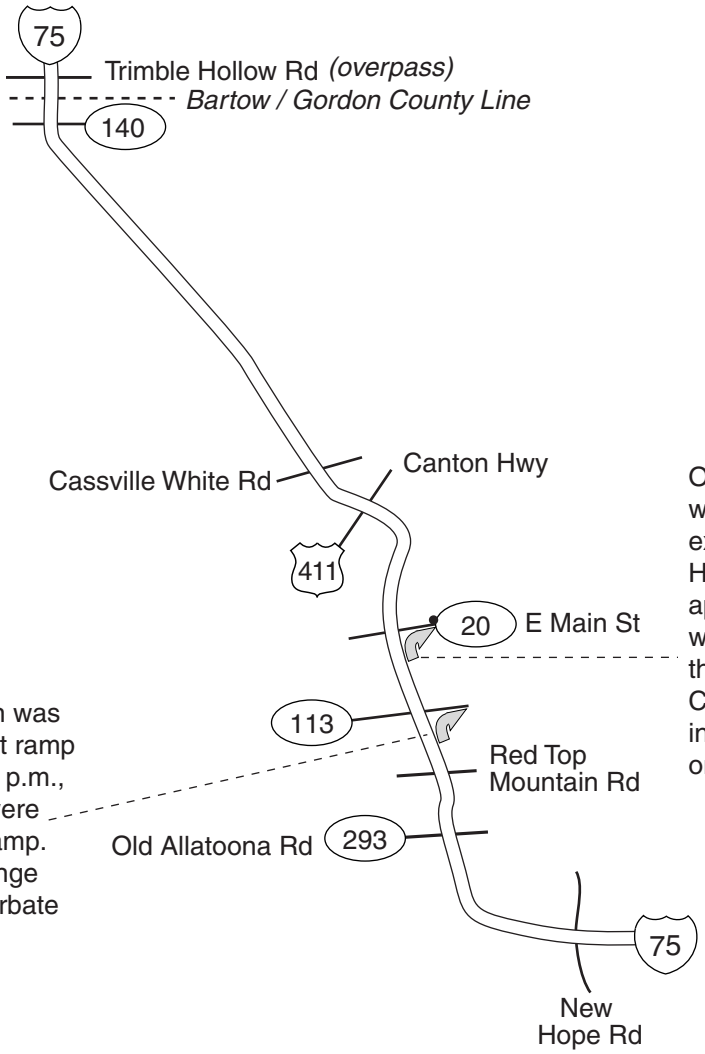
During the peak period, northbound congestion was typically found on US 41 approaching the signal at S. Marietta Pkwy; when congested, queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)


US 41 NORTH
EVENING
(Bartow / Cobb Counties)
SOUTHBOUND
NORTHBOUND
4:00 p.m.
5:00 p.m.
6:00 p.m.
7:00 p.m.
41
411
61
113
293
92
285
75
1 Miller Ferry Rd
2 Old Dixie Hwy
3 US 411
4 US 411 / 61
5 Main St
6 SR 293
7 SR 92
8 Acworth Duewest
9 Rutledge Rd
10 Barrett Pkwy
11 N. Marietta Pkwy
12 S. Marietta Pkwy
13 Windy Hill Rd
14 I-285
15 I-75
C C B
C B B
D D C
D D C
C C C
C C B
C D C
C D D
D D D
C D C
C C D
D D D
D D D
C C C
C C B
C B B
D E D
E E C
D D C
C D C
D D D
C E E
E F E
E F E
D E D
E E E
E E D
D D C

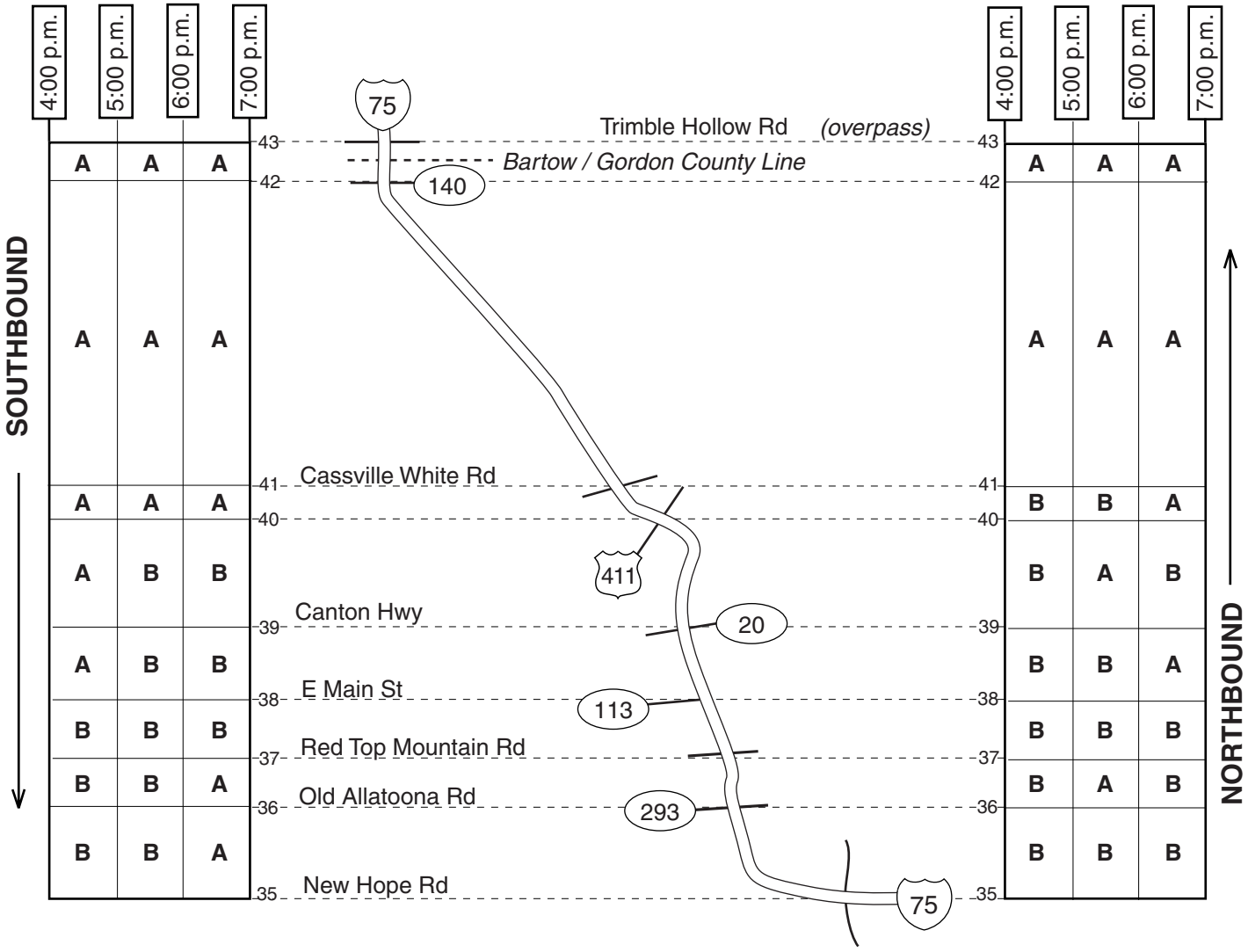
I-75 NORTH
EVENING
(Bartow County)



On one day only, congestion was found on the northbound exit ramp at SR 113 (Main St); at 5:25 p.m., approximately 30 vehicles were queued at the head of the ramp. Construction at the interchange appeared to cause or exacerbate the congestion.

On one day only, congestion was found on the northbound exit ramp at SR 20 (Canton Hwy); at 5:26 p.m., approximately 20 vehicles were queued at the signal at the head of the ramp. Construction at the interchange appeared to cause or exacerbate the congestion.

I-75 NORTH
EVENING
(Bartow County)



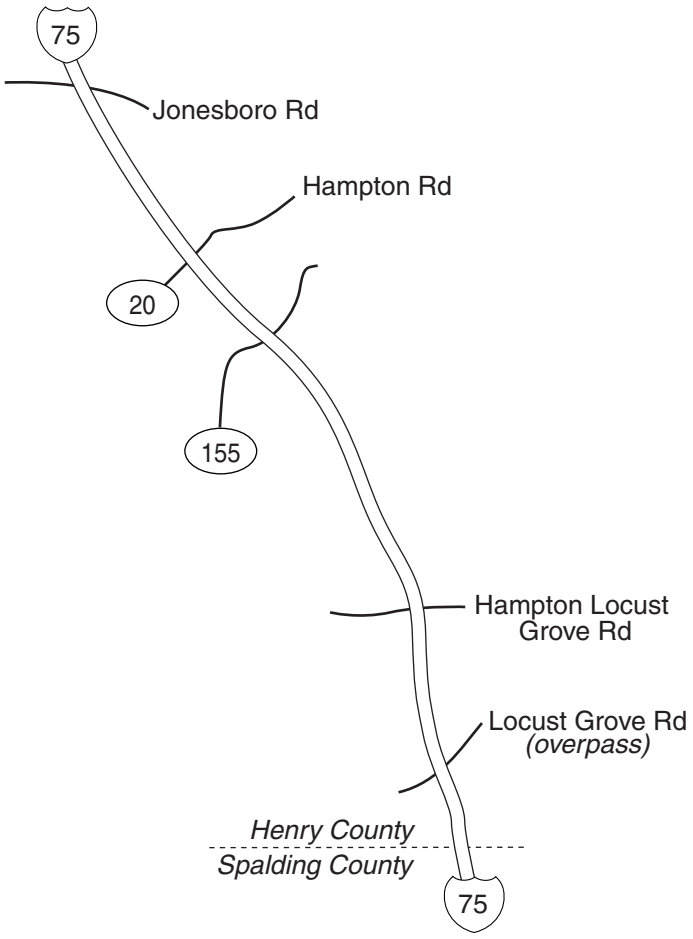
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F		F
0	10	20	30	45	65		

Density scale (cars per lane-mile)

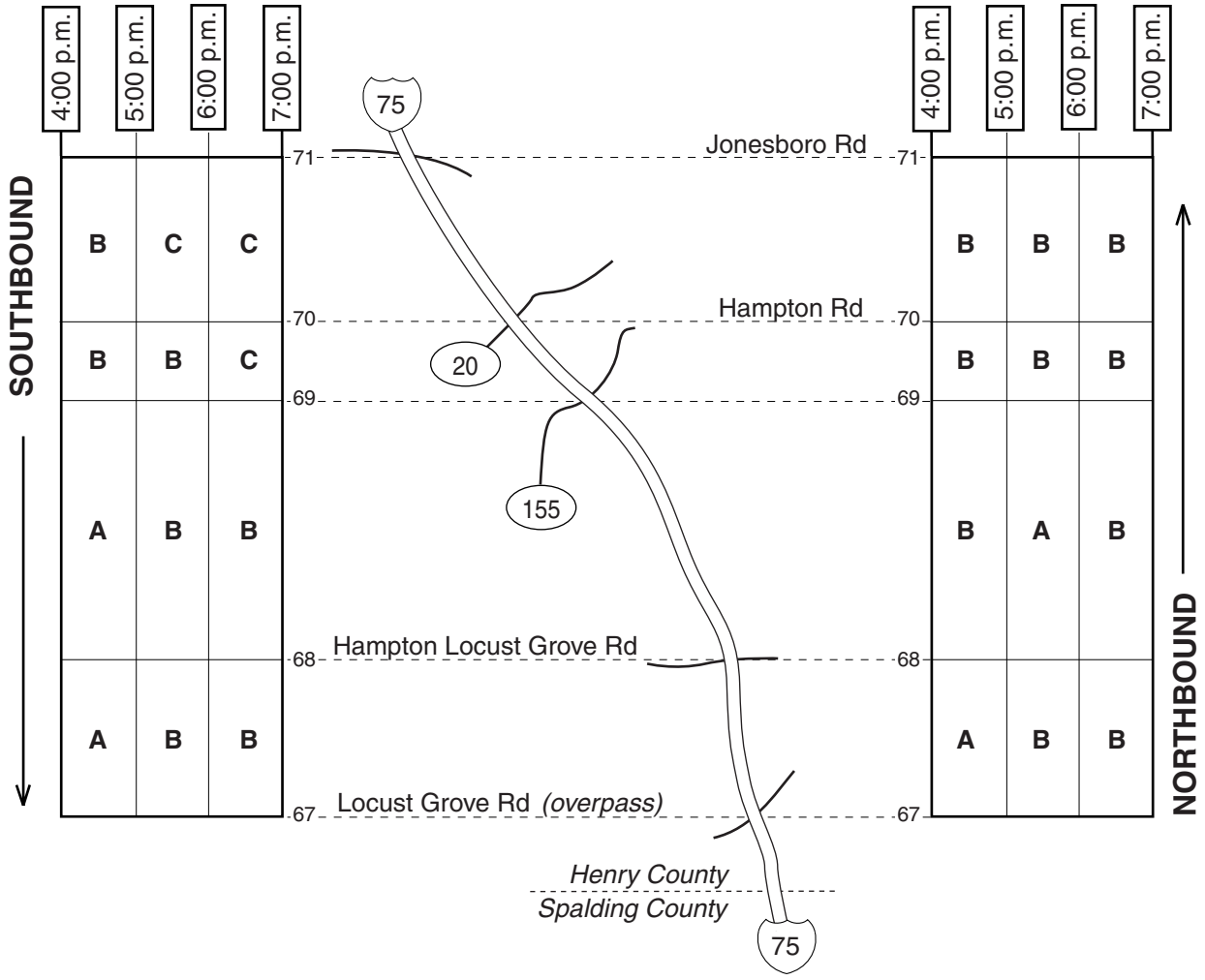
Note: F (60) in the tables means level-of-service "F", with density = 60

I-75 SOUTH
EVENING
(Henry County)



No congestion was found on I-75 South during the evening survey period.

I-75 SOUTH
EVENING
(Henry County)



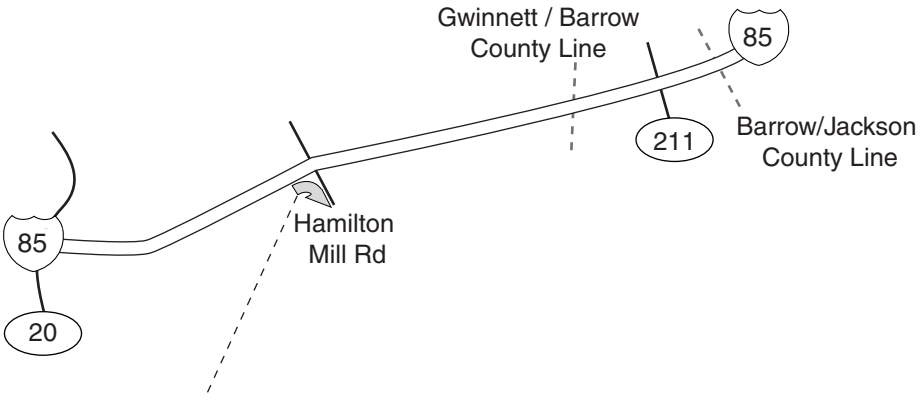
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

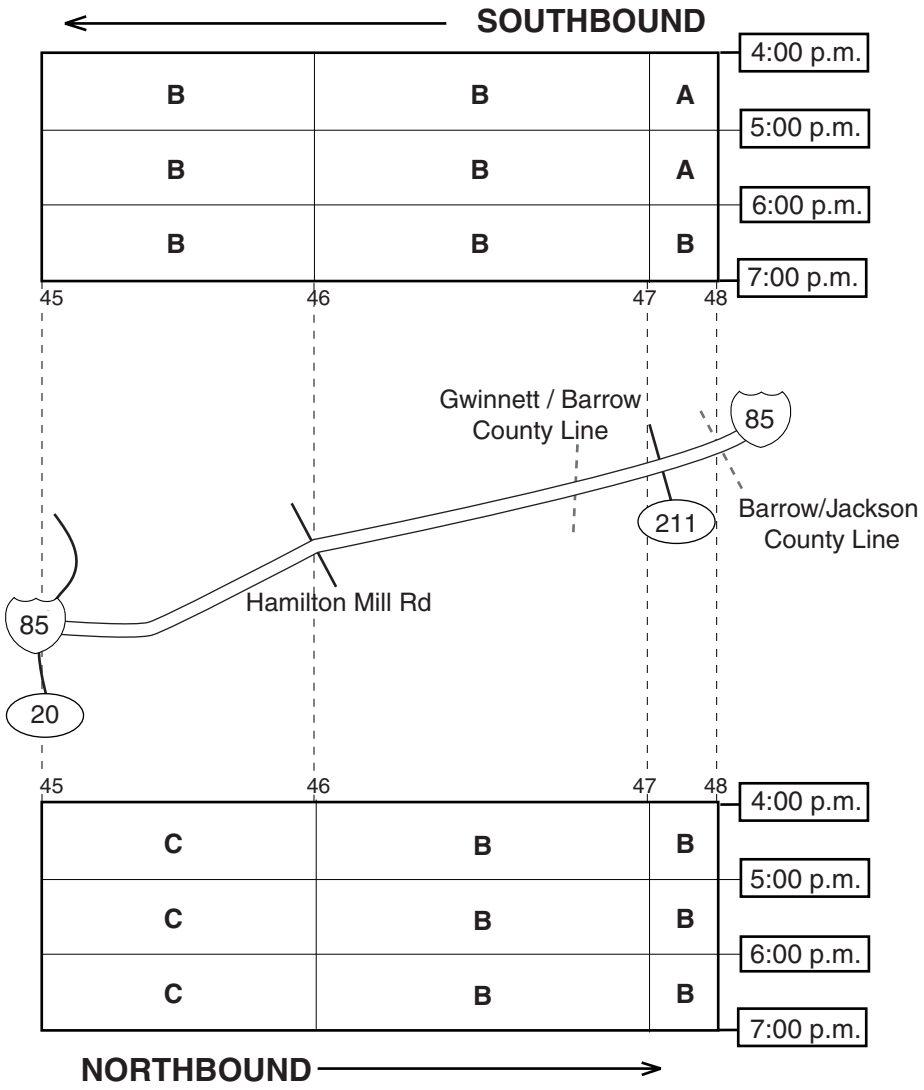
Note: F (60) in the tables means level-of-service "F", with density = 60

I-85 NORTH
EVENING
(Gwinnett / Barrow Counties)



On one day only, congestion was found on the northbound exit ramp at Hamilton Mill Rd; at 5:42 p.m., approximately 30 vehicles were queued at the head of the ramp.

I-85 NORTH
EVENING
(Gwinnett / Barrow Counties)



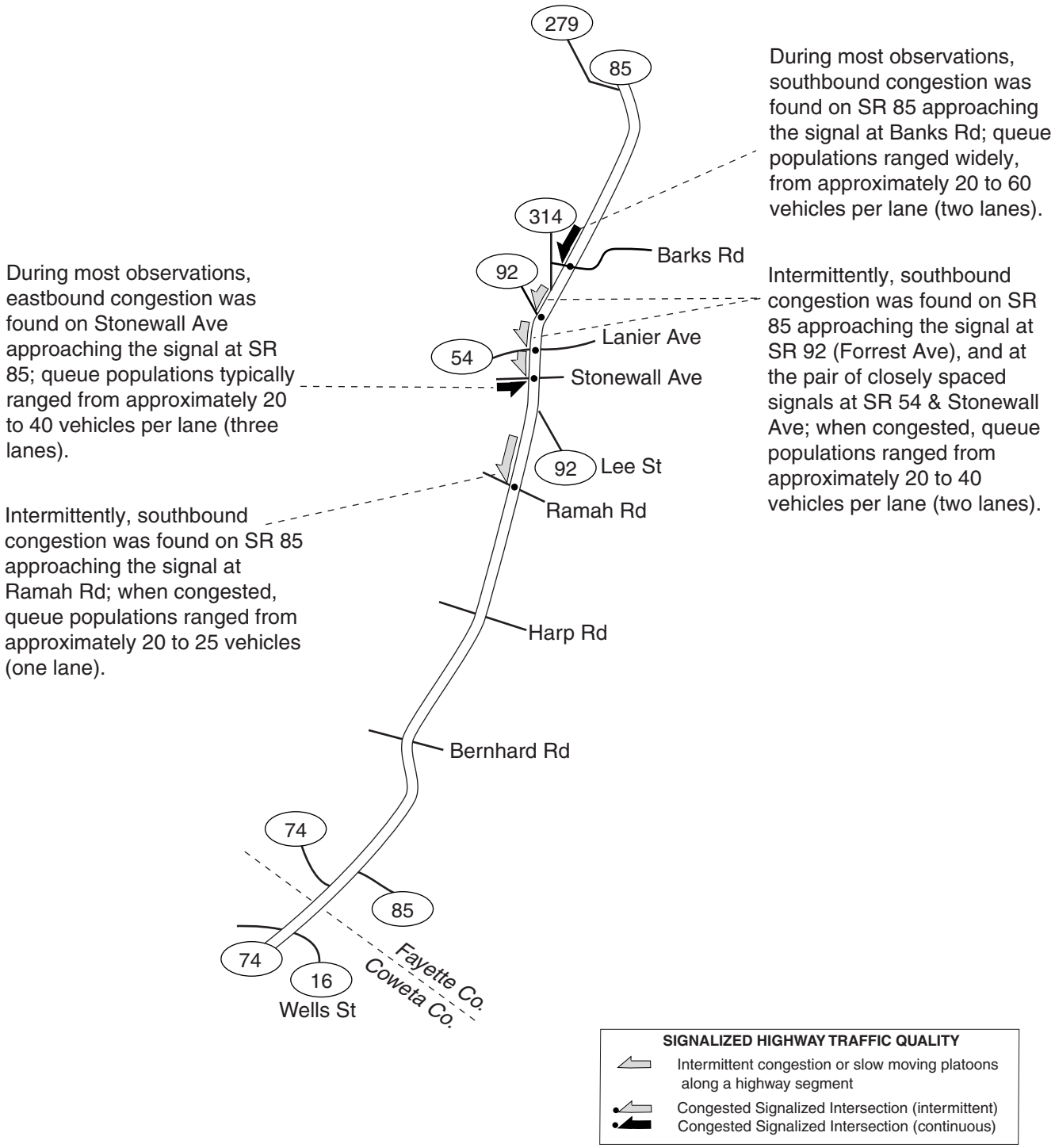
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E	F		F
0	10	20	30	45	65		

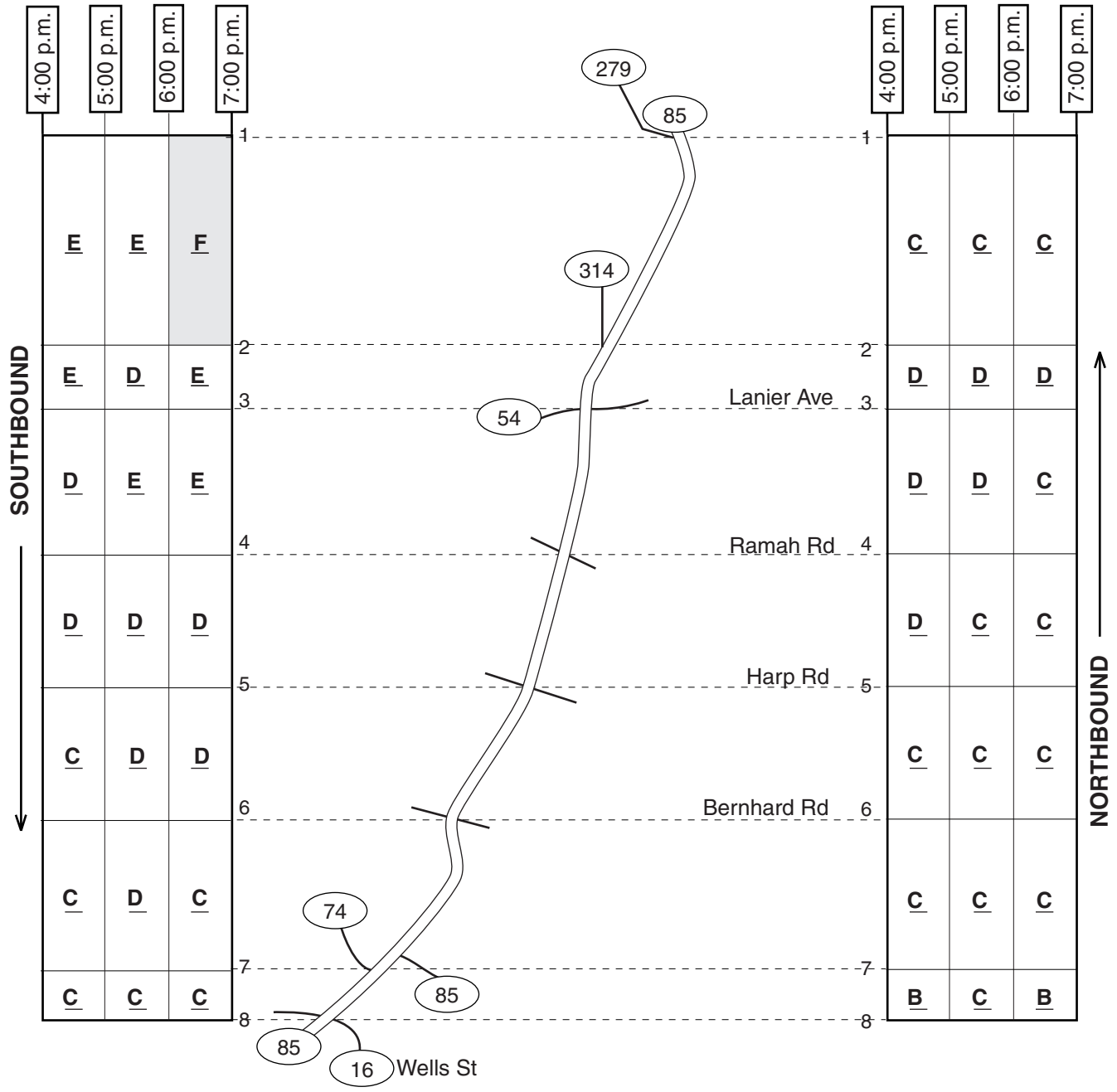
Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

SR 85 SOUTH
EVENING
(Fayette County)



SR 85 SOUTH
EVENING
(Fayette County)



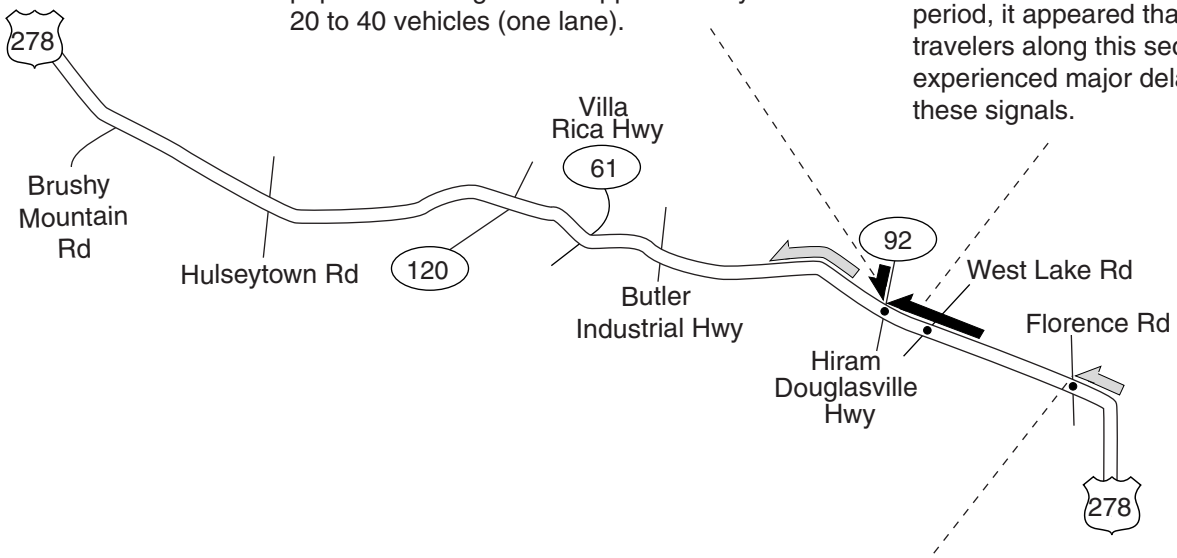
SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

US 278
EVENING
(Cobb / Paulding Counties)

Throughout the evening survey period, westbound congestion was found on US 278 approaching the pair of signals at West Lake Rd and SR 92; queue populations ranged widely, from approximately 30 to 60 vehicles per lane (two lanes). In some cases, congestion at SR 92 backed through the upstream signal at West Lake Rd. During the peak period, it appeared that westbound travelers along this section of US 278 experienced major delays clearing these signals.

During most observations, southbound congestion was found on SR 92 approaching the signal at US 278; queue populations ranged from approximately 20 to 40 vehicles (one lane).

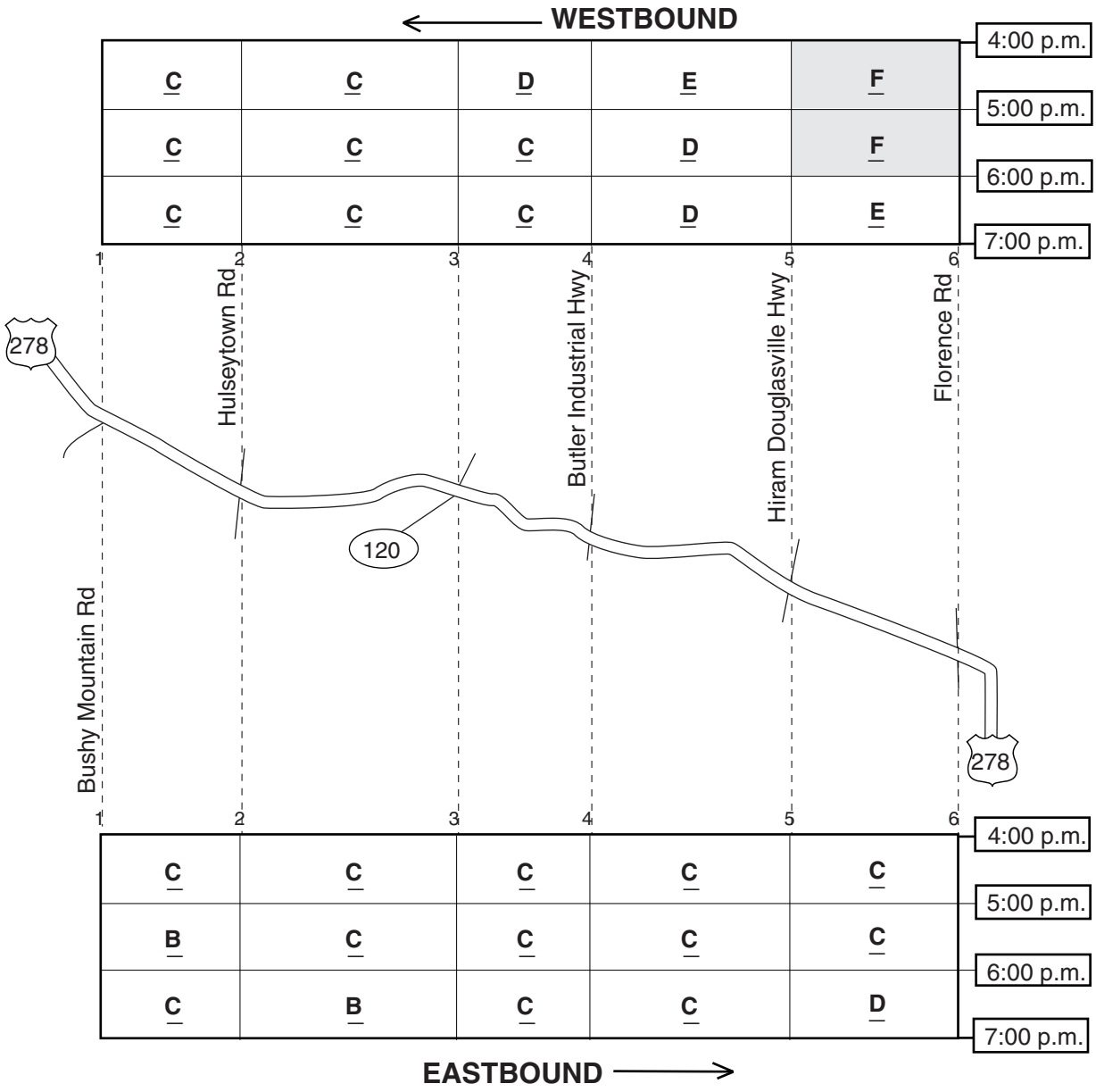


Intermittently, westbound congestion was found on US 278 approaching the signal at Florence Rd; when congested, queue populations ranged from approximately 20 to 25 vehicles per lane (two lanes).

SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

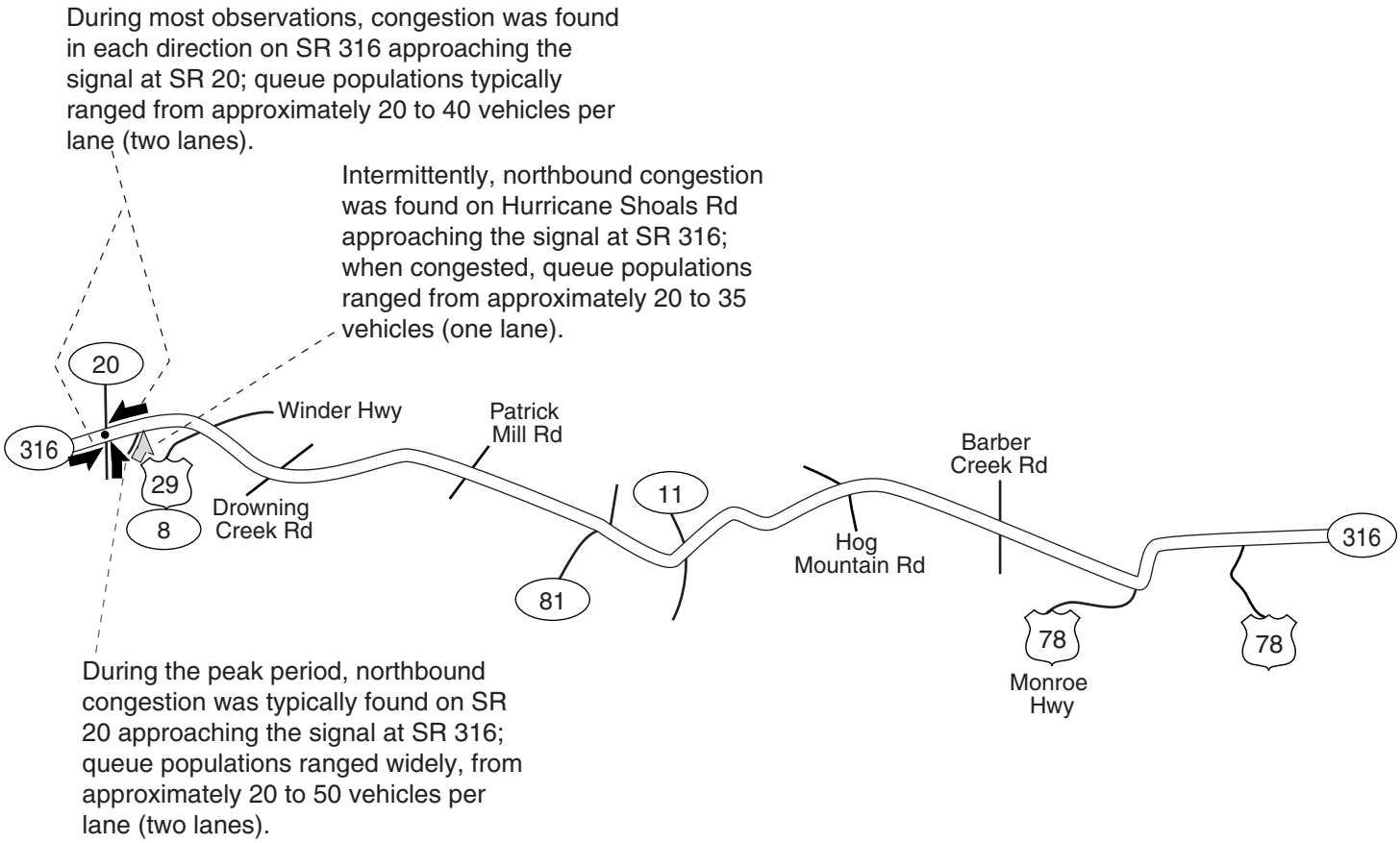
US 278
EVENING
(Cobb / Paulding Counties)



SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

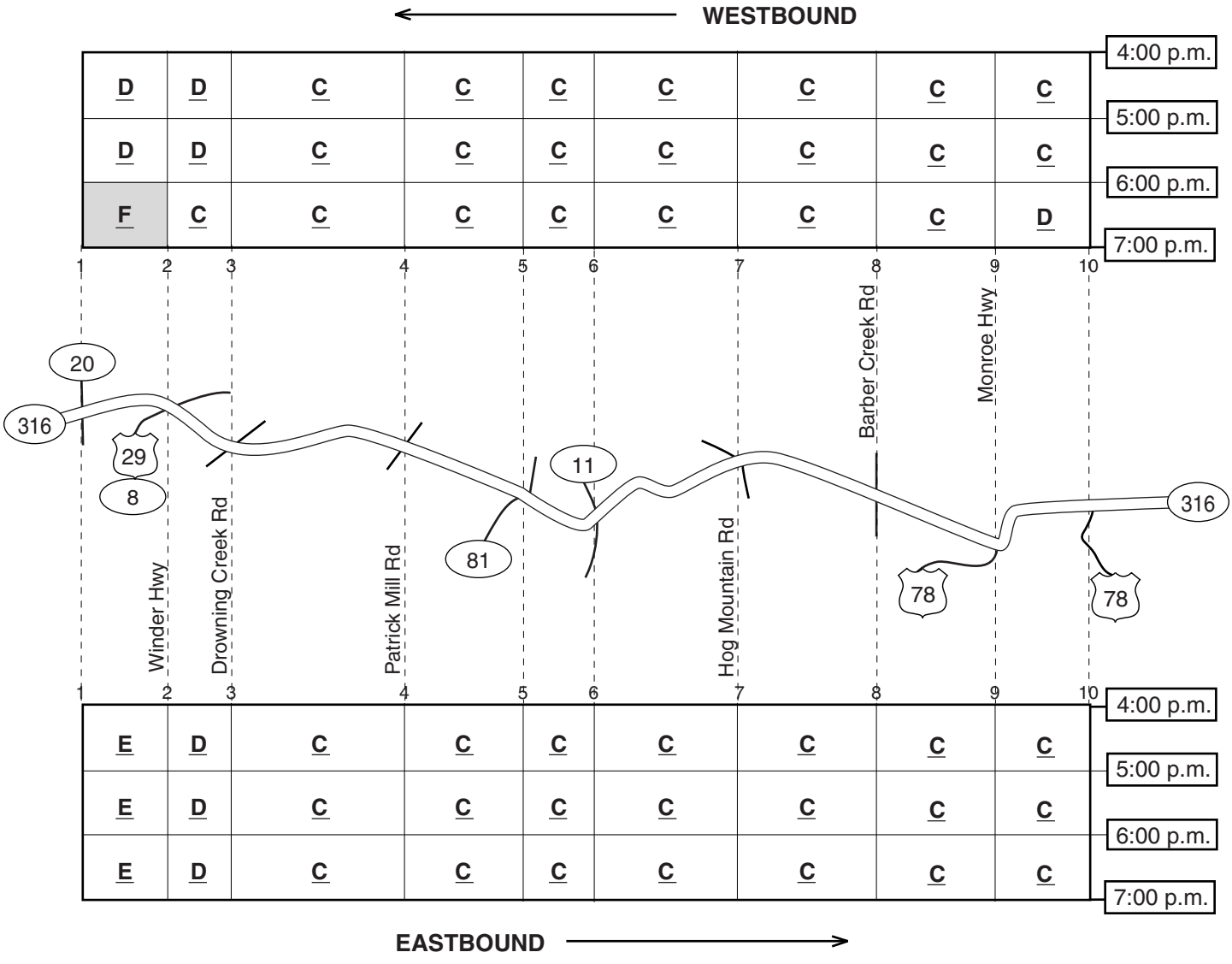
SR 316
EVENING
(Gwinnett / Barrow Counties)



SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

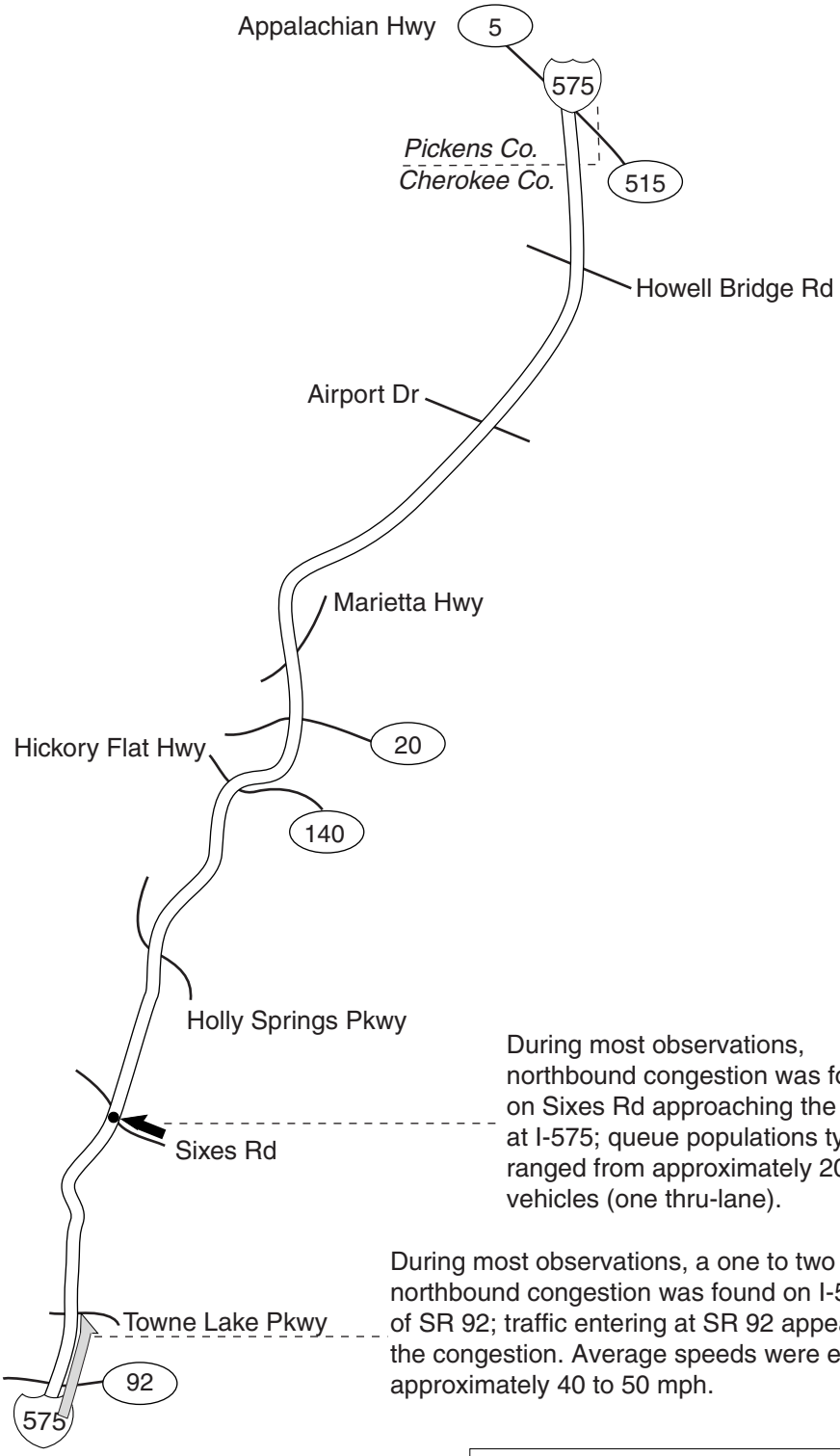
SR 316
EVENING
(Gwinnett / Barrow Counties)



SURROGATE LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY	CONGESTED
A	B	C	D	E	F

I-575
EVENING
(Cherokee County)



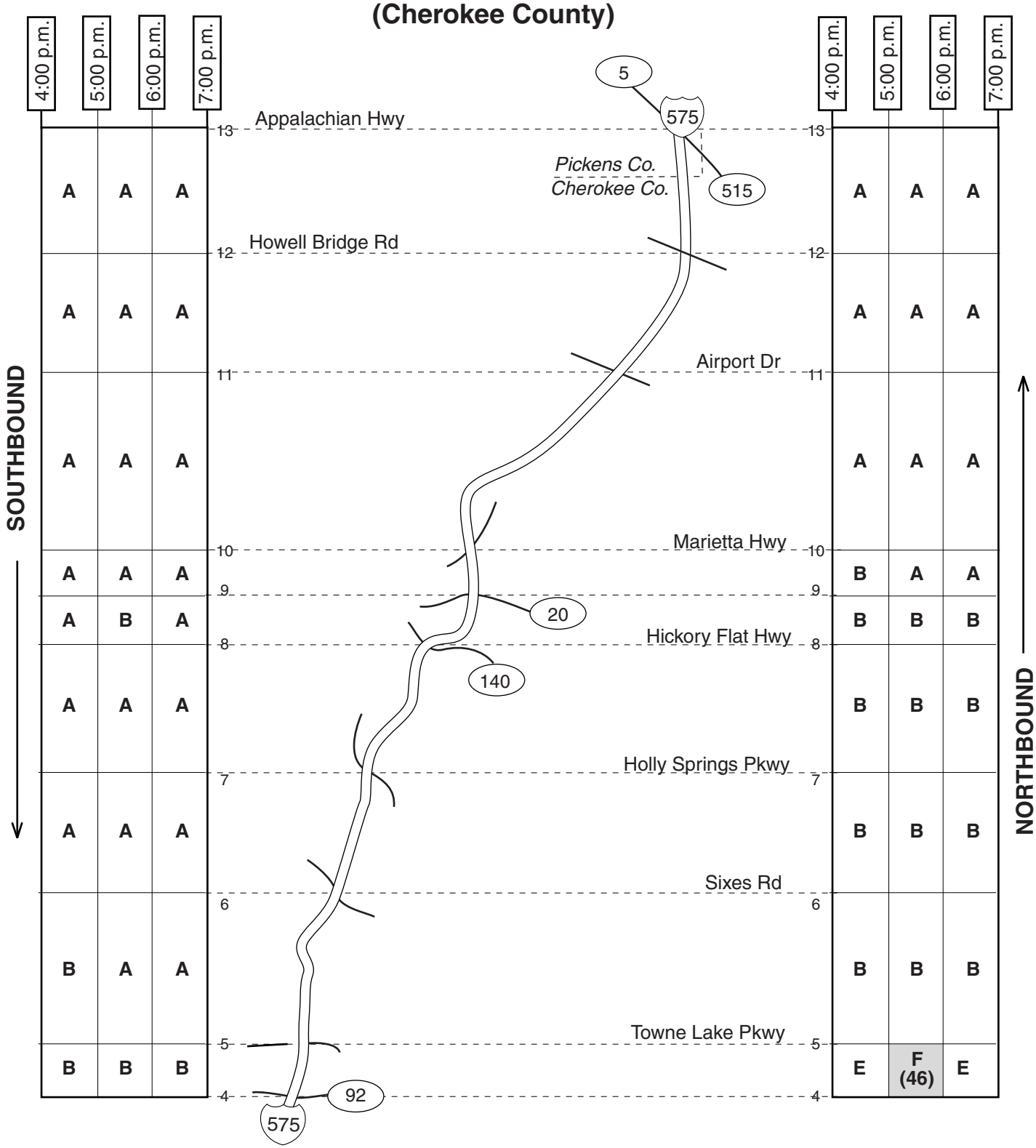
During most observations, northbound congestion was found on Sixes Rd approaching the signal at I-575; queue populations typically ranged from approximately 20 to 25 vehicles (one thru-lane).

During most observations, a one to two mile zone of northbound congestion was found on I-575 in the vicinity of SR 92; traffic entering at SR 92 appeared to cause the congestion. Average speeds were estimated at approximately 40 to 50 mph.

HIGHWAY TRAFFIC QUALITY

Congested flow at average speeds of 30-50 mph
Congested flow involving varying degrees of stop-and-go (average speeds < 30 mph)

I-575
EVENING
(Cherokee County)



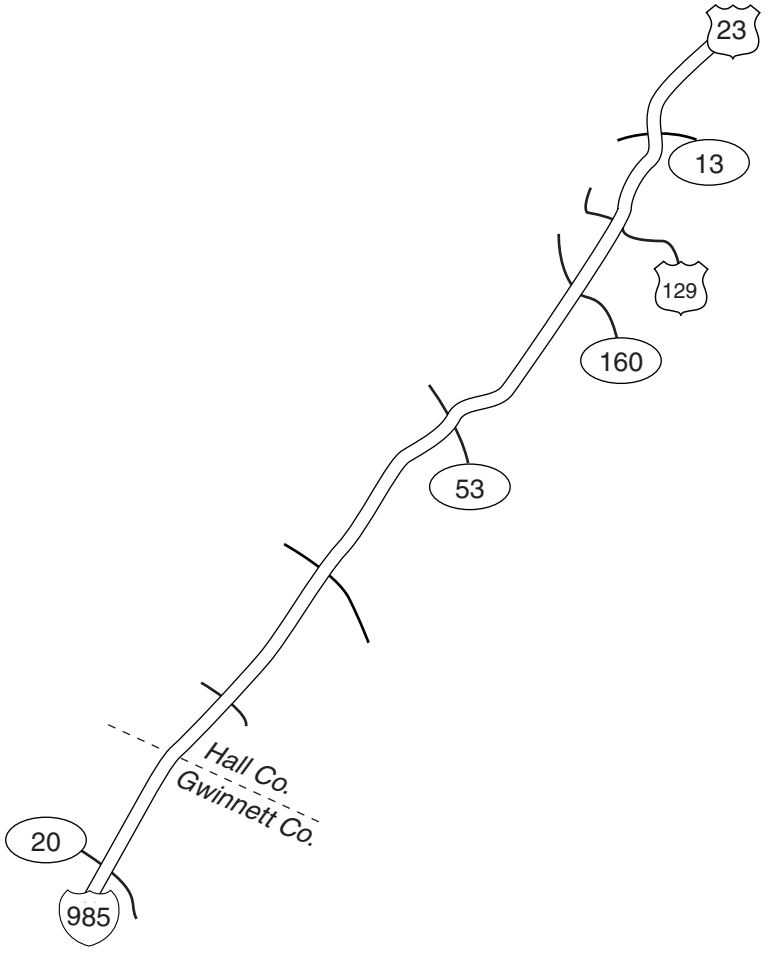
LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED		SEVERE
A	B	C	D	E	F			F
0	10	20	30		45		65	

Density scale (cars per lane-mile)

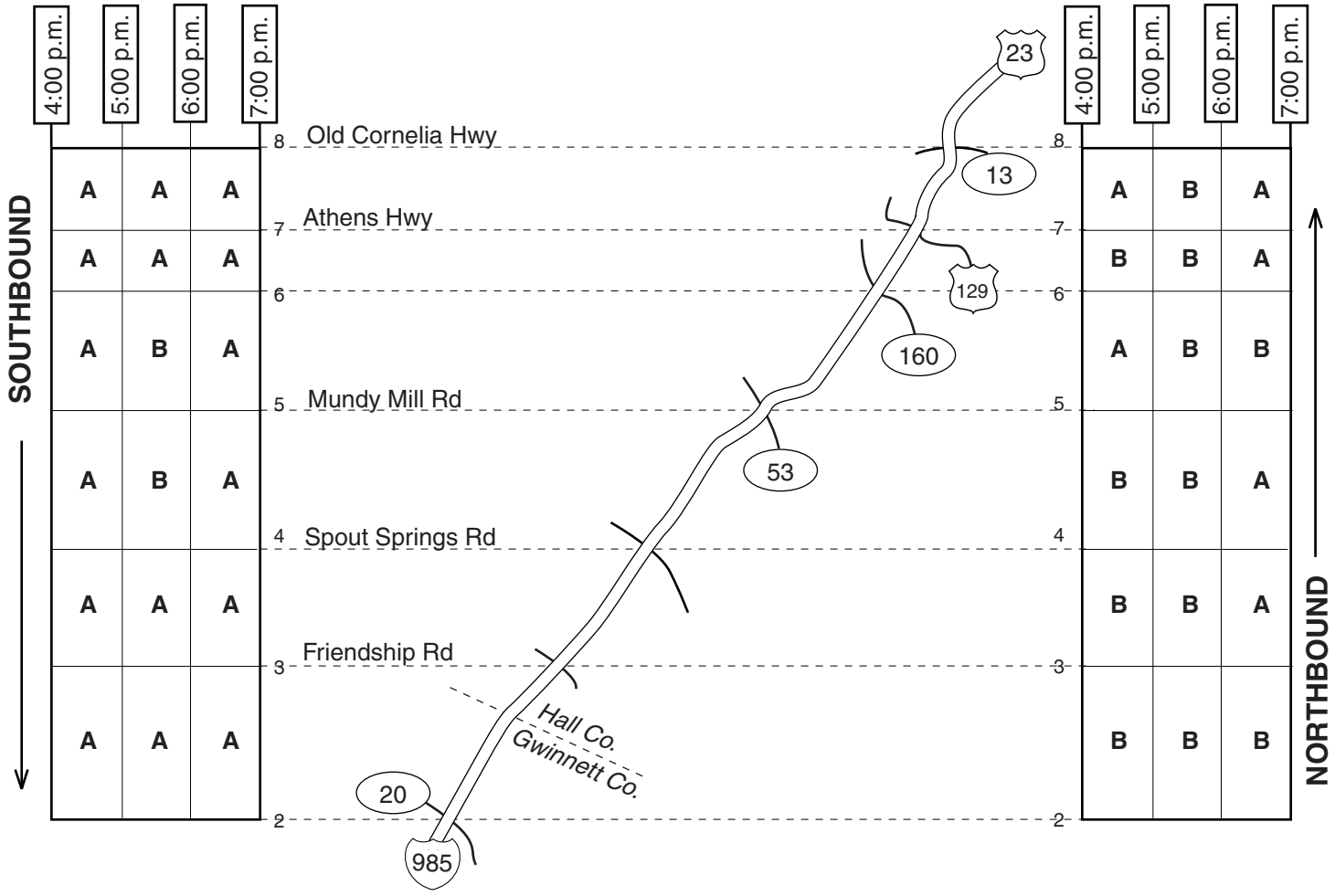
Note: F (60) in the tables means level-of-service "F", with density = 60

I-985
EVENING
(Gwinnett / Hall Counties)



No congestion was found on I-985 during
the evening survey period.

I-985
EVENING
(Gwinnett / Hall Counties)



LEVEL-OF-SERVICE LEGEND:

LIGHT		MODERATE		HEAVY		CONGESTED	SEVERE
A	B	C	D	E		F	F
0	10	20	30		45	65	

Density scale (cars per lane-mile)

Note: F (60) in the tables means level-of-service "F", with density = 60

APPENDIX A

PROCEDURES FOR DETERMINING FREEWAY LEVEL-OF-SERVICE

METHODOLOGY DESCRIPTION

PERFORMANCE MEASURE: DENSITY-BASED LEVEL OF SERVICE

According to the *2000 Highway Capacity Manual* (the HCM), the defining parameter of freeway level-of-service is density, measured in units of passenger-cars per lane per mile (pcplpm). While densities are commonly calculated from speed and volume data, another method is to measure densities directly from aerial photographs. This is the approach used in the Atlanta survey program.

The LOS rating system uses the letters "A" through "F" to describe traffic conditions: LOS "A" represents superior traffic conditions (very light traffic), while LOS "F" represents poor traffic conditions (congested flow involving various degrees of delay). These letters are assigned based on how densely cars are traveling on the road. Research has shown that for all densities below 40 pcplpm, vehicles generally move at or close to normal highway speed; LOS "A" through "E" represent these densities according to the following table (pcplpm):

LOS "A": densities from **zero to 11** (very light traffic);
LOS "B": densities from **12 to 18** (light to moderate traffic);
LOS "C": densities from **19 to 26** (moderate traffic);
LOS "D": densities from **27 to 35** (moderate to heavy traffic);
LOS "E": densities from **36 to approx. 45** (heavy traffic, but still at speeds close to free-flow)

At densities greater than **40**, speeds typically decrease and traveler delays are incurred. Because flow at all densities greater than **46** (approximately) are regarded as LOS "F", this report attaches actual densities to all LOS "F" ratings. Accordingly:

LOS "F":

- Densities from **46 to 60** indicate delay involving minor degrees of slowing; average speeds usually range between 50 and 30 mph;
- Densities from **60 to 80** indicate traffic flow at average speeds usually ranging between 40 and 15 mph;
- Densities from **80 to 100** indicate congested traffic flow, with some stopping possible; average speeds usually range between 10 and 25 mph;
- Densities above **100** indicate severe congestion, with considerable stop-and-go flow likely. For reference, densities above 120 almost always indicate the presence of unusual events (accidents, roadwork, etc.). The practical maximum value for density measurements is **180**; the theoretical maximum value is **264** (at 20 feet per vehicle).

DATA REDUCTION PROCEDURES

From overlapping time-stamped photographs, densities by highway segment were determined by manual counts taken along the entire segment length. Vehicles were classified as cars, trucks, buses, or tractor-trailers when counted; later, passenger-car equivalents (pce's) were derived according to the following table:

Vehicle type:	PCE's:
cars	1
trucks	1.5
tractor-trailers	2.0
buses	1.5

Data that were atypical due to roadwork or to known or suspected incidents were coded for exclusion from the averaging process. All data were then entered into a microcomputer database program, which performed the following tasks: 1) samples were grouped by time slice; 2) average densities were calculated; and 3) densities were converted into service levels "A" through "F". The computer then prepared matrices showing each averaged service level rating plotted by time and highway segment. These data matrices were then copied into the traffic quality tables, which are provided in this report.

In the tables, all LOS F conditions (congested traffic flow) have been outlined and shaded; this permits quick identification of locations experiencing demand at levels exceeding capacity. Because LOS "F" encompasses a wide range of densities, the actual density values are entered next to the "F"; using the travel characteristics in the density ranges provided above, the nature of the flow in LOS F segments can be determined.

While examining the photography, data technicians also identified side streets and on/off ramps that were congested. Where these problems were recurring, descriptive narratives were prepared. These narratives, together with other observations, are provided on "narrative" maps set opposite each traffic quality table.

PROCEDURES FOR DETERMINING ARTERIAL HIGHWAY TRAFFIC CONDITIONS

METHODOLOGY DESCRIPTION

Due to the interrupted nature of traffic flow on signalized highways, density is usually not a preferred performance measure for traffic quality. This is because long segments of roadway often contain few or no vehicles, not for lack of demand, but because vehicles are intermittently held at signalized intersections.

For this and other reasons, the defining parameter for arterial highway level-of-service is travel time over distances of at least one mile in downtown areas and at least two miles in other areas (refer to the *2000 Highway Capacity Manual*). This measure cannot be obtained efficiently across a large region by a fast-moving airplane.

On the other hand, various levels of traffic conditions can easily be seen from above. Trained aerial observers can clearly and consistently differentiate between highways that are lightly, moderately, and heavily traveled. Furthermore, bottlenecks are easily found from above; the more severe the problem, the better it shows up in aerial photographs.

Thus Skycomp has developed a *qualitative* measure of traffic flow on arterial highways, to be applied through examination of 100% overlapping photographic coverage of each highway segment. This methodology and the accompanying rating scale was developed to satisfy the following objectives:

- the rating scale cover the full range of traffic conditions on arterial highways, from empty to densely congested streets, with reasonable gradations in between;
- the methodology be repeatable such that different persons would generally assign the same ratings when viewing the same photographs;
- the ratings are not sensitive to photographs being taken at various points in the signal cycle;
- for ratings that indicate "congestion", descriptive narratives could be attached which qualify the ratings and which designate supporting photography;
- the methodology be reasonably consistent with the descriptions of the six service levels in the HCM (but without regard to the travel-time criteria, which are the defining parameter).

Because of the last objective, a six-point scale was chosen, also using the letters "A" through "F". Skycomp's arterial performance ratings have been underlined in order to designate them as service level surrogates, rather than service level measurements).

Thus the performance rating scale used in this report is defined as follows:

Performance Rating A:
— very few cars using the roadway; or deserted roadway. *[HCM description for LOS A: Vehicles are seldom impeded in their ability to maneuver within the traffic stream; free-flow operations.]*

Performance Rating B:
— light traffic flow; little or no platooning. *[HCM description for LOS B: reasonably unimpeded operations; ability to maneuver only slightly restricted.]*

Performance Rating C:
— moderate traffic flow; not heavy, not light. Platoon populations not greater than 15 vehicles per lane. *[HCM description for LOS C: stable operations; some restrictions to ability to maneuver.)*

Performance Rating D:
— heavy traffic; many cars on the road. Significant queuing at signals, but all should clear on green (less than 20 vehicles per lane queued at all signals). Platoon populations typically between 15 and 25 vehicles per lane. *[HCM description for LOS D: borders on unstable flow where small increases in flow may cause substantial decreases in arterial speed.]*

Performance Rating E:
— congested traffic. Segment may contain one or two intersections with queues of more than 20 vehicles per lane (all may not clear on green). Platoon populations greater than 25 vehicles per lane. On long one-lane segments, the movement of vehicles may resemble a funeral procession, with little opportunity for side-traffic to enter the roadway. *[HCM description for LOS E: significant delays and low average travel speeds; typical causes include adverse progression, high signal density, high volumes, extensive delays at critical intersections, and inappropriate signal timing.]*

Performance Rating F:
— severely congested traffic; includes: vehicles backing through an upstream signal, or for the length of the segment; a series of intersections with more than 20 vehicles per lane queued at each; segment containing one severely congested intersection, with more than 40 vehicles per lane queued approaching the signal (may take two or more signal cycles to clear the intersection). *[HCM description for LOS F: flow at extremely low speeds; high delays and extensive queuing likely at critical intersections.]*

The primary evaluator was trained to view each segment in its entirety (lay out photos side-by-side), and start by testing whether a rating of "C" was appropriate for the segment. Working from this "C" rating, the evaluator could then adjust the rating upward or downward as warranted by the conditions.

In the event that an incident or temporary roadwork significantly affected the rating, the evaluator attached a code which would exclude the affected data from averaging with the results of other days.

After a quality-control review by the project manager, all ratings were digitized and entered into a computer database program for evaluation and averaging. Ratings were printed by time slice and by day, so that unusual ratings could be identified. If there were odd results (for example, "B" ratings on three days and an "F" rating on one day), the photography was checked for possible error or incident. If the data were clearly atypical but a cause could not be identified, a code "u" ("unknown") was attached to the data (like the incident and roadwork codes, this would also exclude the data from averaging).

Data were then output once again as averages, and entered into the traffic condition tables shown in the main body of the report. It should be remembered that these ratings are averages, and thus a location with intermittently severe congestion may get the same rating as locations with steady less-severe congestion. For this reason, descriptive notes have been provided on the opposing pages, which qualify all "congested" ratings.

APPENDIX B

METHODOLOGY DESCRIPTION

Procedures for obtaining speed/density samples for calibration of
the Van Aerde Speed / Density Model

BACKGROUND

In the spring of 1995, Skycomp collected data to compare the speed of vehicles through congested freeway zones with corresponding densities obtained from aerial photographs. The purpose was to explore the relationship between the two, and, given a reasonable correlation, to prepare a model by which vehicle speeds could be estimated from aerial density photographs.

The program was conceived and executed by the Metropolitan Washington (D.C.) Council of Governments (MWCOG). Aerial data were collected by Skycomp; analysis of the data and calibration of the Van Aerde speed/density model were conducted by MWCOG (draft paper included in this appendix).

A secondary objective was to evaluate the accuracy of aerial speed and density measurements by comparing them to data collected by traditional methods (floating cars and loop detectors embedded in the pavement).

Accordingly, segments of freeway were chosen to be surveyed that: 1) were expected to generate congested traffic flow; and 2) either contained a loop detector station or would accommodate quick turnarounds for multiple floating car runs. Thus, while data were being collected in the air (290 speed samples were obtained from the air, along with corresponding densities), loop detector or floating car data were collected concurrently on the ground.

The outcome of this study was a finding that travel speeds across congested freeway segments could be determined with reasonable accuracy using only aerial density photographs. It was also found that speeds and densities obtained through aerial techniques closely matched data obtained using the traditional ground methods.

PROCEDURES TO OBTAIN SPEED / DENSITY SAMPLES:

The observer/photographer followed the following procedure to obtain all speed/density samples: he first flew along the selected survey segment while taking time-stamped overlapping density photographs of the entire segment; next, at the upstream end, he selected a target “floating” car for tracking; he photographed the target as it entered and departed the segment, while simultaneously timing its run to the nearest second. He then took an “after” density photo set; and then recorded the following information on a clipboard: the time of the sample, the target vehicle description, lane(s) traveled, elapsed time, and any special notes. This procedure was repeated for each speed/density data point.

In the actual course of sampling, this procedure was modified in several ways. First, where cars were moving at high (free-flow) speeds, the density did not change significantly between samples; thus sometimes three or more floating cars were timed between density runs.

Another modification done in-flight is as follows: the observer noted in several cases that the density set taken before the target vehicle went through better reflected the conditions the car encountered than the density set taken after the vehicle went through (or vice versa). This was usually due to a delay in changing film, extra maneuvering the airplane, or any other event which delayed the "after" density sample for several minutes after the completion of the run. While normally the density associated with each speed sample was an average of the "before" and "after" density sets, in these cases only the "before" or "after" density set would be used (as directed by the observer).

With regard to selection of target vehicles, the plan was to select cars that reflected the average speed of traffic, just as floating car drivers are instructed to approximate the speed of traffic flow. Fortunately, vehicles have little freedom to choose their speeds in the congested density ranges (above 40 pcplpm). So, for example, almost any vehicle in a congested traffic stream in the middle lane of three will give a suitable floating car measurement. Even tractor-trailers (unless heavily loaded and traveling uphill) moved at the same speed as passenger cars. Thus the criteria the observer used in selecting each target vehicle was 1) is it in the correct lane; and 2) does the vehicle stand out so that it is easy to keep track of?

Also, in the event that the highway had four travel lanes in one direction, alternating samples were taken from both middle lanes.

In the event that a driver switched lanes while being tracked, the observer noted the lane change and also noted which lane the car spent the majority of time in (this is the lane for which a density count would be made later). In several cases (infrequently), the observer abandoned tracking certain vehicles when: 1) the driver made multiple lane changes, trying to beat the average speed of traffic; 2) the driver switched lanes and changed speeds obviously and significantly; 3) the vehicle turned out to be a heavily loaded truck which delayed the traffic stream; or 4) the observer "lost" the vehicle being tracked. Also, for the samples made with traffic traveling at free-flow speeds, vehicles were abandoned which proved to be traveling significantly faster or slower than the average speed of traffic.

In the event that the target vehicle moved to the right lane in apparent preparation to exit, the observer often was able to switch tracking to another vehicle that had been just behind or ahead of the original vehicle in the same lane (and used the newly adopted vehicle to complete the sample). This was necessary because in some cases six or seven minutes had been invested in the tracking of a specific vehicle, and it was important to avoid wasting that time where possible.

It should also be pointed out that speeds were not tracked for very slow moving queues (densities over 120 / MWCOG samples only). Instead, density runs were made at 5 or 10 minute intervals, such that later on the ground the same vehicles could be found in succeeding sets of density photos; this allowed computation of speeds and associated densities.

DATA PROCESSING

After each flight, a topographic map was prepared for each zone which showed the starting and stopping points for each tracked car. Measurements were then made of the segment length (distance traveled). Then each tracked vehicle was entered into the computer database, including:

1. vehicle description
2. time-of-day
3. initial lane and subsequent lane changes
4. precise travel time (from stopwatch or time-lapse photographs)
5. density-photo preference, if any (default was to average the before- and after- density samples)
6. any special notes pertaining to that vehicle.

After the photos had been processed, each set of overlapping "density" photographs was taped together into a "mosaic" that showed each entire segment. Then vehicles in the required lane(s) were counted, listed by "car", "truck", "tractor-trailer" and "bus". These totals were translated into passenger-car equivalents (PCE's) using the following values:

Vehicle type:	PCE's:
cars	1
trucks	1.5
tractor-trailers	2.0
buses	1.5

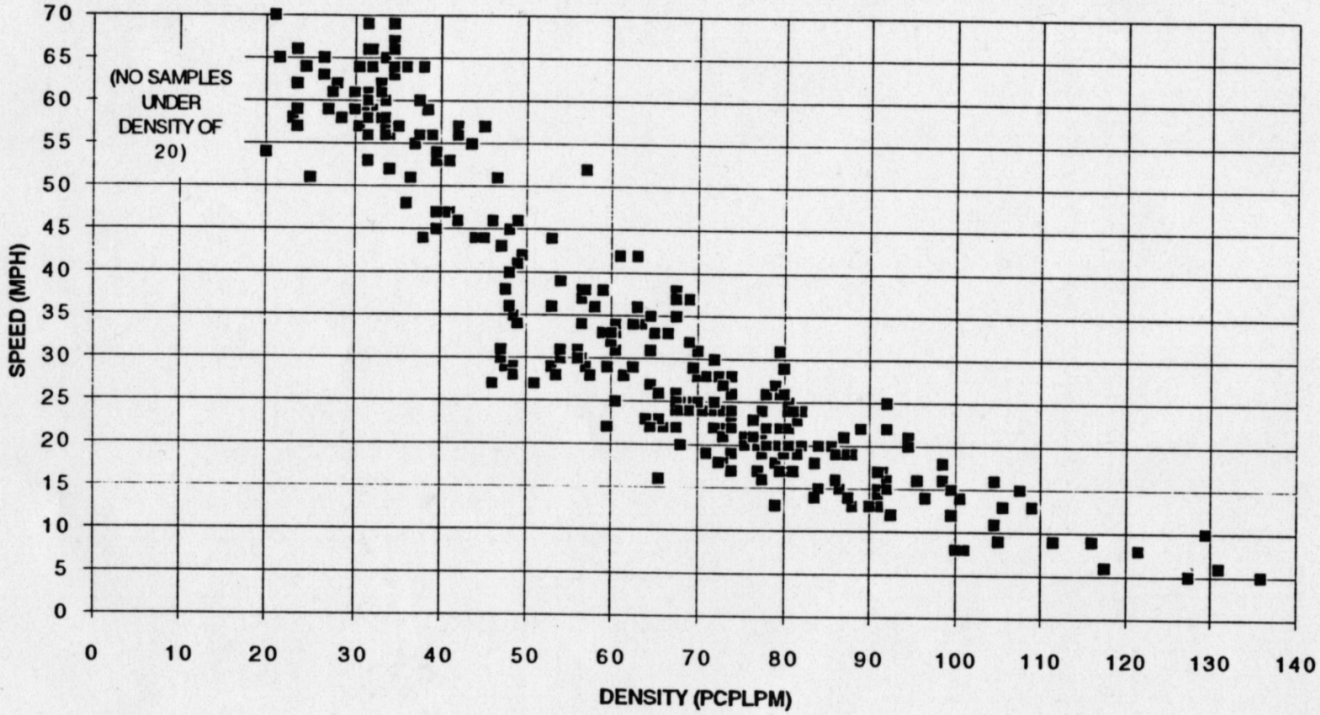
(It should be noted that the distinction between "cars" and "trucks" could not be cleanly made, since there are many varieties of light and heavy pick-ups (both covered and uncovered). In general, a pick-up or van had to be at least twice the size of an average-sized car to be considered a "truck".)

PCE's were then divided by segment length to calculate densities. These density samples were then matched to corresponding speed samples; each speed/density data pair was then plotted on the chart.

CALIBRATION OF THE VAN AERDE MODEL

The latest draft of the MWCOG paper describing the calibration of the Van Aerde Speed / Density Model for the Washington D.C. metropolitan area is provided next. This paper was authored by Paul DeVivo, the member of MWCOG staff who performed the analysis.

ALL SKYCOMP DATA SAMPLES



Van Aerde Model
DRAFT -- 15 Feb 96

The main advantages to a single-regime model are that boundaries between regimes do not have to be defined; and curves from adjacent regimes do not have to be spliced at the boundaries. A single-regime model allows for a more subjective and repeatable calibration process. This will be is especially true if more data from the high-speed end of the curve is ever incorporated into this process.

The disadvantages to this particular model are that it expresses this project's independent variable as a function of the dependent variable; and that it is a non-linear function. These disadvantages make performing the initial calibration more difficult. However, once SAS programs for the task are written, they can be used again usually with a minimum of effort.

The procedure for calibration was as follows: 1) The model's equation was coded into a spreadsheet so that the shape could be defined by recognizable parameters: two points that the curve passes through, the free-flow speed, and the speed at capacity. By overlaying this curve with the scatter plot of the observations, initial estimates of the parameters were made. 2) The initial parameter estimates, the equation, and the observations were used in a SAS PROC NLIN job to machine-calibrate the parameter estimates. 3) A second SAS program translated the calibrated equation into a look-up table that expresses speed as a function of density. 4) The results of the SAS work were imported into a spreadsheet for plotting and for calculation of prediction intervals.

Two outstanding technical issues related to this procedure are determination of the free-flow speed, and calculation of prediction intervals.

The free-flow speed for best fit can be determined by the PROC NLIN program, as are all other parameters. Due to the lack of data at the low-density region of the model, PROC NLIN returns a very high free-flow speed. Additional data from MD SHA was used to calculate a free-flow speed for general application on the Beltway. The calibration of the model presented here resulted from forcing the free-flow speed to match the SHA data analysis.

The prediction intervals shown in the current plot were calculated after the model was translated. This may have not been appropriate. PROC NLIN calculates prediction intervals directly as it calibrates the model. Those prediction intervals express density as a function of speed, however. Work is in progress to translate them, and to otherwise arrive at the most appropriate method of determining prediction intervals.
Since a single-regime model is more suitable in a computerized process, and for lack of significant difference in performance, the Van Aerde model is preferred over earlier approaches examined by MWCOG staff and presented before subcommittees.

Van Aerde Single Regime Model
DRAFT--2 May 1996

This model was developed by Michael Van Aerde and described in TRB Paper No. 950802. It differs from the models already presented in two significant respects: 1) The Van Aerde model expresses headway or density as a function of speed instead of speed as a function of density; 2) The Van Aerde model's single regime is continuous for the entire speed range from jam to free-flow.

The model is:

$$D = 1 / (c1 + c2 / (Sf - S) + c3 * S)$$

where:

D = Density (vehicles/lane/mi)

Sf = Free-flow speed (mph)

c1, c2, c3 = coefficients

S = Speed (mph) -- INDEPENDENT VARIABLE

The model was calibrated for local use by MWCOG staff. Maryland SHA ATR data from stations on the Capital Beltway was used to determine the free-flow speed. Skycomp aerial speed/density observations were used to calibrate the coefficients.

The calibration resulted in the curves shown in the attached graphics: Speed vs. Density; Flow Rate vs. Density; Speed vs. Flow Rate; and Speed Residuals vs. Density.

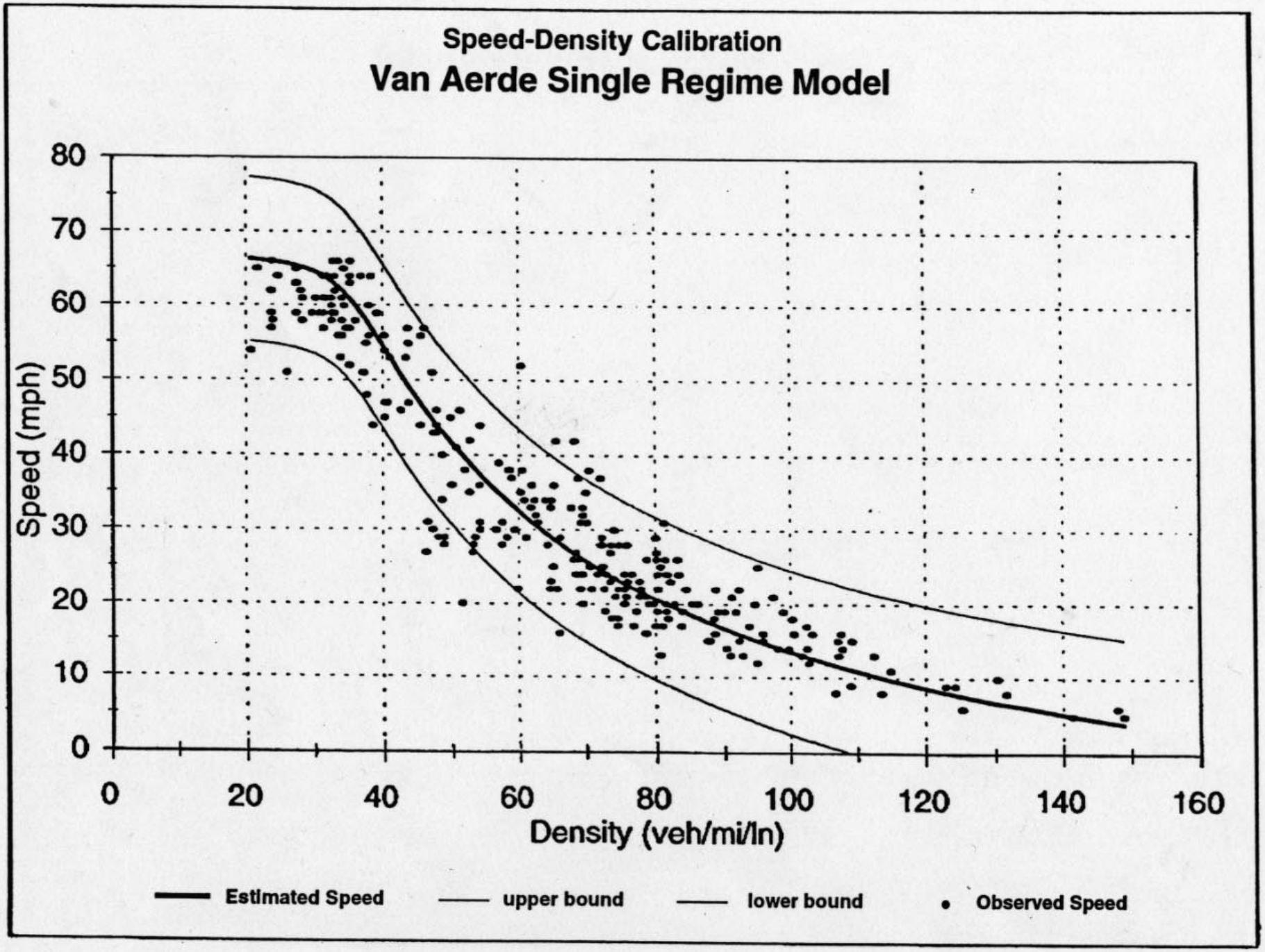
The coefficients required to plot the Density vs. Speed curve are 0.00512, 0.0144, and 0.000342, respectively. The free-flow speed is 67 mph. All trucks were weighted as 2.5 cars. The upper and lower bounds shown on this plot are 95% prediction intervals.

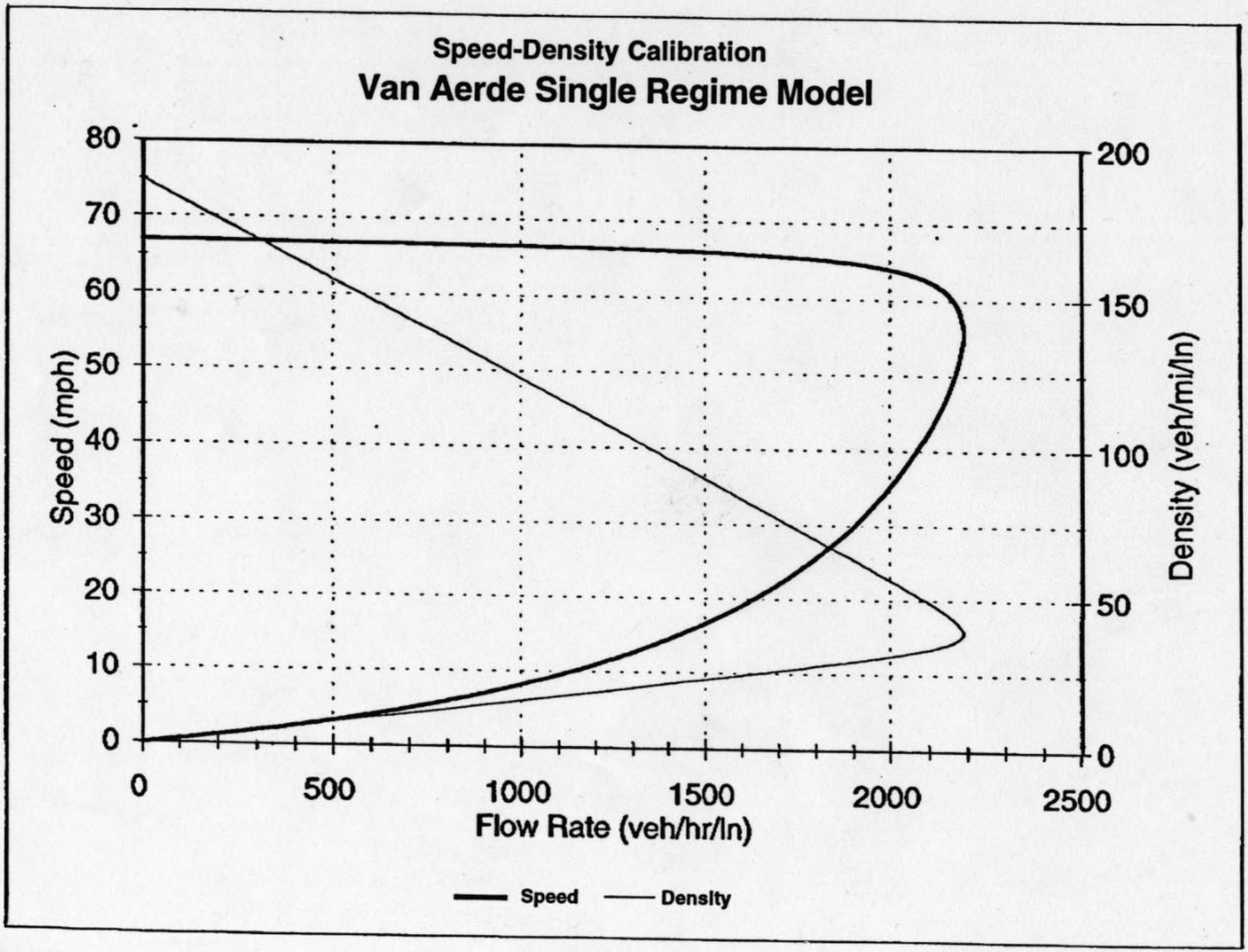
Speed-Density Calibration
Van Aerde Single Regime Model

free-flow spd = 67 mph / c1 = 0.00512 / c2 = 0.0114 / c3 = 0.000342

	DENSITY (veh/ln/mi)	SPEED (mph)	VOLUME (veh/ln/hr)
free-flow	0	67.0	0
	20	66.4	1,328
	25	65.8	1,661
	30	64.6	1,946
	35	61.3	2,144
capacity	39	55.8	2,190
	40	54.7	2,189
	45	47.8	2,153
	50	41.9	2,094
	55	36.8	2,025
	60	32.6	1,954
	65	28.9	1,880
	70	25.8	1,806
	75	23.1	1,731
	80	20.7	1655
	85	18.6	1580
	90	16.7	1503
	95	15.0	1425
	100	13.5	1350
	105	12.1	1271
	110	10.9	1197
	115	9.7	1117
	120	8.7	1043
	125	7.7	963
	130	6.8	885
	135	6.0	810
	140	5.2	729
	187	0	0 jam

Draft 15 February 1996


Speed-Density Calibration
Van Aerde Single Regime Model
Speed (mph)
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
120
140
160
Density (veh/mi/ln)
Estimated Speed
upper bound
lower bound
Observed Speed


Speed-Density Calibration
Van Aerde Single Regime Model
Speed (mph)
80
70
60
50
40
30
20
10
0
Density (veh/mi/ln)
200
150
100
50
0
0
500
1000
1500
2000
2500
Flow Rate (veh/hr/ln)
Speed
Density

APPENDIX C

FLIGHT DIRECTORY

FLIGHT #	DAY OF WEEK	DATE	MORNING/EVENING
1	Tuesday	May 14, 2002	Morning
2	Tuesday	May 14, 2002	Evening
3	Wednesday	May 15, 2002	Morning
4	Wednesday	May 15, 2002	Evening
5	Thursday	May 16, 2002	Morning
6	Wednesday	May 15, 2002	Evening
7	Friday	May 17, 2002	Morning
8	Tuesday	May 21, 2002	Morning
9	Tuesday	May 21, 2002	Evening
10	Wednesday	May 22, 2002	Evening
11	Thursday	September 19, 2002	Evening
12	Friday	September 20, 2002	Morning